April 1941

APR 10 1941

MACHINE DESIGN

In This Issue:

Machine Drives and Controls

Engineering Department Equipment

Powder Metal Machine Parts

CUTLER-HAMMER

UNITROL

C-H

A *New and* Better *Answer for Builders of Machines*

Every manufacturer of motorized machines who is looking for manufacturing economies, simplified assembly operations, the sales power of streamlined appearance and increased customer satisfaction is invited to give thoughtful consideration to *UNITROL*.

UNITROL is a new, better way of *assembling* Motor Control. UNITROL is a new and better way of *installing* Motor Control. UNITROL is a new and better way of *connecting* and *wiring* Motor Control.

UNITROL is what electrical engineers have aimed at for more than 25 years . . . and is the exclusive product of Cutler-Hammer, Incorporated, *pioneers* in Motor Control Progress.

The basic unit of UNITROL is the familiar Cutler-Hammer Motor Control Unit such as you may now be using in any of your machines. It is any *standard*, skeletonized form of Cutler-Hammer Motor Control. But it employs a new type of mounting frame, designed especially for "built-in" machine mounting.

If you build Motor Control into your machines, the standard skeletonized Motor Control complete with its Unitrol mounting frame may be employed "as is". It saves space... time... wiring difficulties... and costs. It eliminates many special machine cavities and provides a new Motor Control interchangeability.

But if you build a machine requiring several control units per machine; then you are interested in the next step of UNITROL construction . . . This is a new, specially designed *sectional* housing, built to house Unitrol Motor Control Units of varying shapes, sizes and characteristics. Built to house them more compactly, more conveniently, more efficiently, more economically than anything you have ever dreamed of.

There's so much to tell about the advantages of UNITROL, it would fill a book. In fact, it *has* filled a book called "UNITROL—the Next Step Forward in Motor Control" free to any interested business executive. And the premium placed on manufacturing economies, short-cuts and improvements today certainly warrants your sending for a copy *now*. Just say: "Send a copy of your UNITROL Book at once." CUTLER-HAMMER, Inc., *Pioneer Electrical Manufacturers,* 1310 St. Paul Ave., Milwaukee, Wisconsin.

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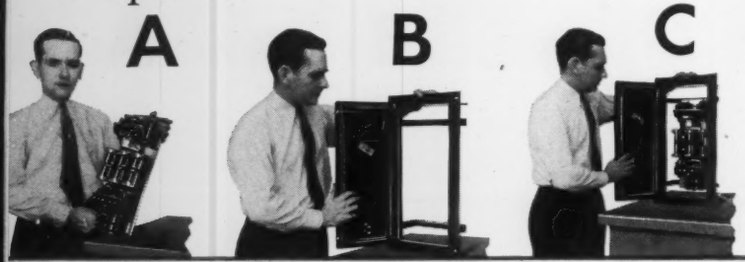
Simple as:



Any standard skeleton C-H Starter.

UNITROL mounting frame, showing door and starter mounting straps.

Standard Starter mounted in place in UNITROL frame—Ready for use as*

*As "built-in" Control

*As member of SINGLE Unitrol Section

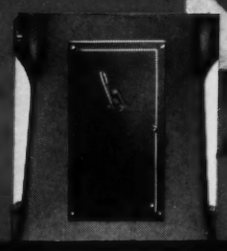
*As member of MULTIPLE Sections or UNITROL CONTROL CENTER.

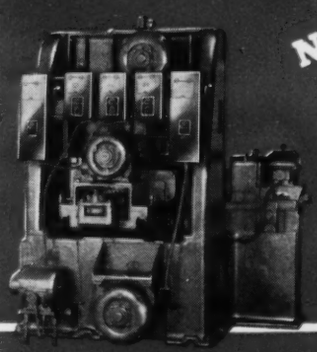
NOT THIS!

This illustrates common practice of building control into a machine... and brings up questions of size of cavity, how to mount the control, the difficulties of wiring, a door which must be hung, machined, pierced for buttons, etc.

BUT THIS!

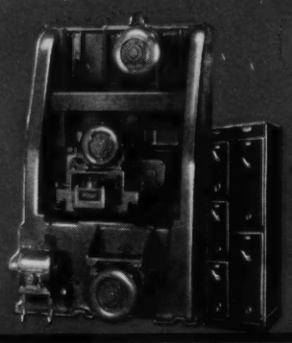
UNITROL answers these questions and licks the difficulties. A Cutler-Hammer Control . . . a *standardized* UNITROL Mounting Frame, complete with door, hinges, a cavity in machine base —and your control is *built in*. Simple, sensible, economical.





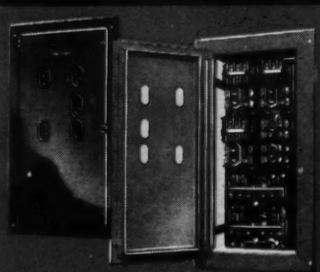
NOT THIS!

Machines often ... than one control ... job of placing the ... problem. Adds ... awkwardness, ... costs and what not.



BUT THIS!

UNITROL ... of motor control ... metered machine. ... Just install them ... compact, flexible ... ardized UNITROL ... tion" and stand ... alongside the ...



Here's Anot...

Another smart UNI... answer for ma... machines is to ... the controls in a ... UNITROL mounting ... —as shown here.

BRUNING "75" PRINTER AND 154 BW DEVELOPING MACHINE

These two machines will provide the high efficiency print production to gear your print department to today's needs. One man can develop 1200 8½ x 11 BW Prints per hour, and two men can develop 2600 8½ x 11 BW Prints per hour.

Prints up to 42" in width, any length, can be handled.

The Bruning booklet, "New Light On Prints," fully describes the "75" Printer and the Model 154 Developer, and gives information about other Bruning printers and developers. Send for your copy.

"No Wonder We Changed to BW Prints!"

• Prints in 45 seconds instead of 2½ minutes! That's why *one* company is now making BW Prints, instead of blue prints!

Today—when you need prints *fast*—you'll get them when you want them by changing to BW. High-speed BW equipment produces prints in two simple operations—exposure and development. The use of cut sheets permits volume production of prints cut to the exact size of your tracings—no lost time in trimming. Remember, too, that BW (black line) Prints are much easier to read and check than blue prints—a big advantage when work must go through in a hurry. Bruning representatives have helped many a plant speed up production all along the line with BW Prints. Perhaps their experience can aid *you*. Get in touch with one soon—and mail the coupon for our free, illustrated booklet explaining BW in detail.

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Topics

EXPERIMENTS on producing aluminum-nickel-iron "alloys" from powder metals have brought enthusiastic comments from P. R. Kalischer of Westinghouse. It is often necessary or desirable to include one or more components that tend to form stable oxides, these metals including manganese, magnesium, silicon, aluminum and others. Sintered compacts of powder metals are not truly alloys, of course, since they are not entirely homogeneous, the components retaining individual characteristics. But often this fact is an asset, and is one of the peculiar qualities of powder metal parts. To provide absolute homogeneity the surface films of oxide on the particles would have to be reduced, and usually this is almost impossible.

♦

CORRONIZING, an electrolytic method of plating, is being boosted as a substitute and method for conserving vital metals needed by the defense program. In the process the base metal is electroplated in succession with two very thin coatings of protective metals, and it is this thinness that results in savings. It is claimed, for instance, that a galvanized sheet, to withstand identical tests, would require a coating of zinc approximately ten times that of a corronized sheet.

♦

WHEN it comes to smart promotion, the welding industry deserves commendation. Competitions like the Lincoln awards have long advanced the cause of welding. Now Summerill Tubing Co., through the American Welding society, is offering cash prizes for papers discussing how welding has been applied to aircraft steels, including tubing and other parts for tubular assemblies. Awards will be made during the society's annual meeting next October, and include one for $300, another $200, and additional ones of $100.

♦

FUNDAMENTAL purpose of a new system for rustproofing metal during production is to provide a passive, resistant iron phosphate surface over which finish coats may be applied cheaply. An inhibitor wash is applied first, cleaning and conditioning in a single operation, and a dip bath follows to give a heavier iron phosphate base. A microscopic thickness of the metal itself is said to be converted to iron phosphate. The dip bath builds up a thicker deposit.

♦

NEW uses for infrared rays, including those for finishing as discussed in M. D. for February, are multiplying rapidly. Among the more unusual is a method developed for heating bearing cones preparatory to assembling them on shafts where a tight press fit is required. Three trays about four inches square are used, the middle one being glass, with about 12 inches between each. Top and bottom trays both carry seven 250-watt infrared bulbs with gold-plated reflectors. Bearing cones are left in cardboard packing boxes, and after about 20 minutes, become heated to a maximum of 155 degrees Fahr. The infrared rays penetrates the boxes, heat the steel, but leave the cardboard relatively cold. It is then unnecessary to wash off the protective coating on the bearings.

♦

TREMENDOUS increase in use of nickel is reflected in the fact that although supplies available for the U. S. market are at record heights, immediate calls by nickel consuming industries greatly exceed the supply now being provided. It is pointed out, however, that this demand is only apparent. Precautionary advance buying has tied up a good deal and many orders are for uses not immediately essential.

♦

AS DURING the World war period, conservation of manganese is a necessity and a recent OPM report suggested use of spiegeleisen instead of ferromanganese as the most important method. Main conservation naturally must take place during actual steelmaking or reduction of ores, but designers can help by specifying alloy steels with less manganese content.

♦

ANOTHER step which may expand this country's useful metal supply is the recent announcement of a furnace for direct reduction of low grade iron ores to nodular iron. Many ranges having an iron content from 30 to 56 per cent iron and from 8 to 20 per cent silica may be reopened.

MACHINE DESIGN

Specifying DESIGN DEPARTMENT MATERIEL

By H. T. Pentecost
General Electric Co.

Part I—Supplies

ALTHOUGH many improvements have been made in design department equipment, no universally ideal drawing medium has been found upon which an engineer can register his thoughts with the first pencil within reach and from which satisfactory prints can be made indefinitely. However, proper selection of engineering department materials and equipment such as discussed in this and subsequent articles make it economically possible to produce nearly all drawings with pencil and paper where only a few years ago expensive ink tracings were required.

Next to the great savings in designers' time and expense, intelligent use of the pencil and paper technique allows substantial economy in drafting material, first and most striking being the substitution

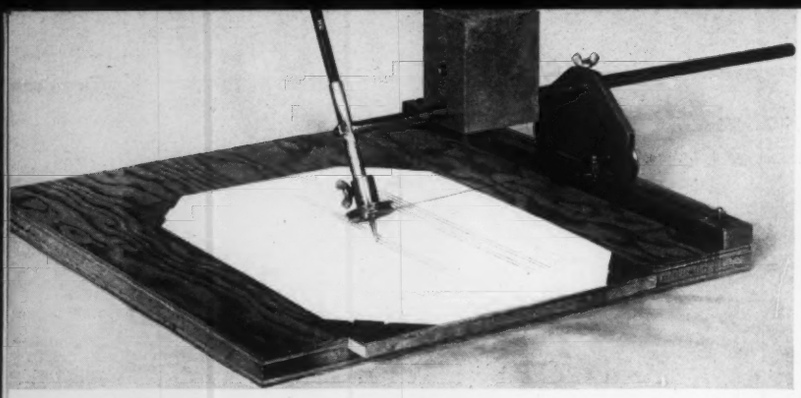


Fig. 1—This "mechanical draftsman" permits exact duplication of drawing technique as a test of papers

of relatively inexpensive pencil papers for ink tracing cloths. These materials fall into four broad classifications, each particularly adapted to one or more drafting or reproducing requirements.

First are the comparatively inexpensive papers of moderate durability and transparency. These are suitable only for temporary drawings such as layouts and sketches from which few if any prints will be made, or from which photo-reproduced originals are immediately desired. Cost and reasonably good transparency together with sufficient strength and suitable surface to allow satisfactory pencil deposit and erasures are first considerations for this class.

The second group contains those papers of 100 per cent rag content. Their outstanding characteristics are strength and wear resistance to withstand the rigors of handling, filing and alteration, with sufficient transparency to permit printing with present-day equipment. Surfaces of this group of papers are better than those of the previous group and are expected to take either ink or pencil. These papers are especially suited for printed form drawings and, because of their longer usable life, are often preferred for the majority of pencil work.

In group three are included most of the so called "treated" papers or those which have been given special impregnating treatments to increase their transparency, improve their moisture resistance and color, or to impart any other quality considered essential or beneficial. Except for good transparency no other single characteristic seems to be predominant since many papers with many different treatments are found here.

Papers in this class are proving worthwhile for special applications and have so nearly approached the ideal of certain users that they have been selected as their standard drafting medium in spite of some objectionable features. Some "treated" papers show exceptional anticreep and shrink properties and are being successfully used for extremely accurate templet work. Most of them take ink and pencil well and erase easily, but many have a tendency to discolor and embrittle with age, to bleed their treating compounds to other drawings in file, and to show opaque marks when wrinkled.

In the fourth group may be placed the pencil cloths. Because of their original cost their use for pencil drawings to replace ink cloth tracings generally results in little material savings, but does, of course, often save the appreciable expense of tracing after drawing. The advantage of pencil cloths lies in their strength and durability, therefore they are used mostly for the larger drawings. Reproduction characteristics are similar to treated papers.

Since no single material has yet been found which possesses all of the desired characteristics for all pencil drawings it may be well first to select, from the general classes listed above, those which will be necessary to fulfill the engineering demands of a particular enterprise. During this selection it will be noted that the order of importance of each char-

FIRST of a series of articles on engineering department equipment, this contribution deals with essential considerations in the proper selection of drawing papers, pencils and erasers. Subsequent articles will treat such other materiel as drawing boards and tables, drafting machines and instruments, blueprinting equipment, etc.

TABLE I

Characteristics of Pencil and Tracing Papers and Cloths

Specification	Class I Less than 100% rag	Class II 100% rag	Class III Special Treated Papers	Class IV Pencil Cloths
Approximate Cost (36" x 50 yd roll)	$2.50 or less	Over $2.50	Over $5.00	Over $15.00
General Purposes	Temporary drawings layouts, sketches, and photo-reproductions	Permanent drawings printed forms cut sheets	Special drawings moisture-proof drawings shrink-proof layouts templates	Permanent drawings large sizes
Characteristics in order of importance	Density and ease of pencil deposit without smudge Ease and perfection of pencil erasure Cost Transparency Printing range Strength and wear resistance Ink deposit Ink erasure Aging	Strength and wear resistance Aging Density and ease of pencil deposit without smudge Ease and perfection of pencil erasure Printing range Cost Transparency Ease of ink deposit Ease of ink erasure Anti-creep and shrink	Bleeding Aging and color change Moisture resistance Anti-creep and shrink Transparency Strength and wear resistance Density and ease of pencil deposit without smudge Ease and perfection of pencil erasure Printing range Ease of ink deposit Ease of ink erasure Cost	Strength and wear resistance Density and ease of pencil deposit without smudge Ease and perfection of pencil erasure Printing range Cost

acteristic will differ between classes in much the same manner as shown in TABLE I. That is, when many drawings are made from which only a few prints are required (and those soon after the drawing is completed), strength and wear resistance and even transparency will follow in importance such items as ease of pencil deposit, erasures and cost. However, if a considerable number of drawings is

TABLE II

Comparative Density of Pencil Lines

Pencil No.	Wood (W) or Auto-Lead (L)	Photometer Reading* for Pencil Hardness HB	F	H	2H	3H	4H	5H
1	W	70	80	100	130	150	165	...
1	L	70	85	105	130	155	165	...
2	W	65	85	110	135	150	160	...
2	L	70	90	120	135	150	165	...
3	W	..	..	...	...	...	...	...
3	L	..	75	100	140	160	...	...
4	W	..	30	40	60	80	110	130
4	L	..	..	...	...	...	...	...
5	W	45	40	45	65	70	80	...
5	L	..	..	...	...	...	...	...
6	W	35	45	50	85	90	120	...
6	L	..	..	...	...	...	...	...
7	W	50	55	60	70	100	165	190
7	L	..	55	60	75	100	160	...
8	W	..	40	65	75	80	110	150
8	L	..	..	...	...	...	...	...
9	W	45	60	70	80	85	130	...
9	L	..	60	75	85	90	120	...
10	W	40	65	70	115	120	140	150
10	L	..	65	65	100	110	120	...
11	W	..	..	55	65	90	...	...
11	L	..	..	50	60	85	...	...

*The average transparency of the test paper is 400.

made for which a number of prints will be needed at periodic intervals, between which the drawings will be actively filed, the order of importance will be as shown under Class 2 or 4. The sequence found under Class 3 will depend largely on the special circumstances under which these drawings will be used.

After their listing, the assignment of adequate values to many of these characteristics can be made with little or no special equipment and often exact values can be obtained from the supplier. These items include strength, color, cost, weight, rag content, etc. On the other hand the measurement of such items as ease of pencil deposit and erasures, transparency, creep resistance, smudging, etc., are more difficult and generally have been left to the judgment of one or more qualified draftsmen.

Since his opinions are chiefly based on the manual operations involved in making drawings on sample materials, even the most experienced draftsman working under the most uniform conditions can describe his results only in very general terms. For the purpose of reducing this human element the author has developed the simple and inexpensive "mechanical draftsman" shown in *Fig.* 1 which has proved useful in preparing sample papers and cloths for further study as well as making possible an accurate test of drawing pencils and leads.

Sample drawings made in this manner, or prints made from these samples, can be compared visually for such items as pencil deposit, opacity of drawn line, quality of erasures, etc. Fairly exact numerical values for these as well as such items as transparency of papers and cloths can be obtained on the photometer shown in *Fig.* 2.

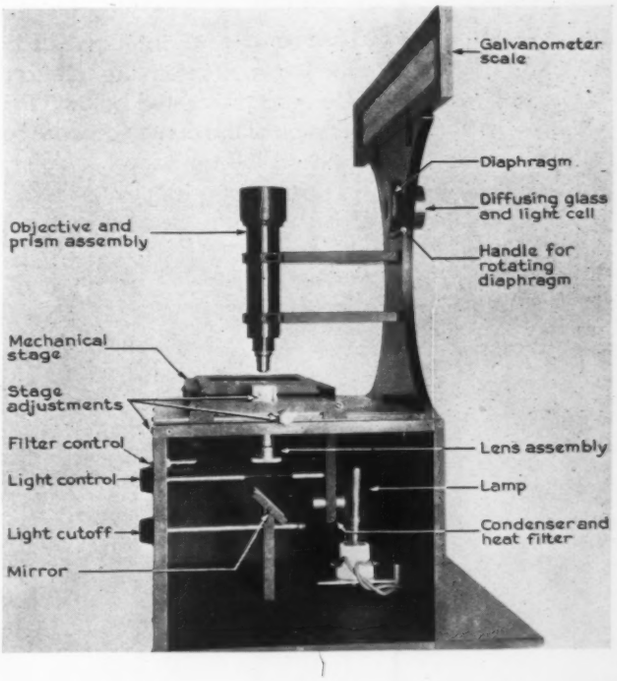
For determining the quality of drawing pencils, a paper showing the least variation in transparency between a number of areas was selected on which all sample lines were drawn. These lines were made with various makes and grades of both foreign and domestic pencils as well as with automatic drawing pencil leads. Opacity of their lines was measured and tabulated as in *Fig.* 4 to form a basis on which to judge deposit and the uniformity of hardness grading. This last should be considered second only to quality consistency.

Many companies have found that domestic pencils are generally softer for equivalent grade hardnesses than foreign brands. For this reason, and in the interest of good pencil drawings and reproductions, draftsmen are often encouraged to use domestic lead at least one grade harder than the equivalent foreign grade. Photometer tests partly justify this contention, particularly in the grades from HB to 3H.

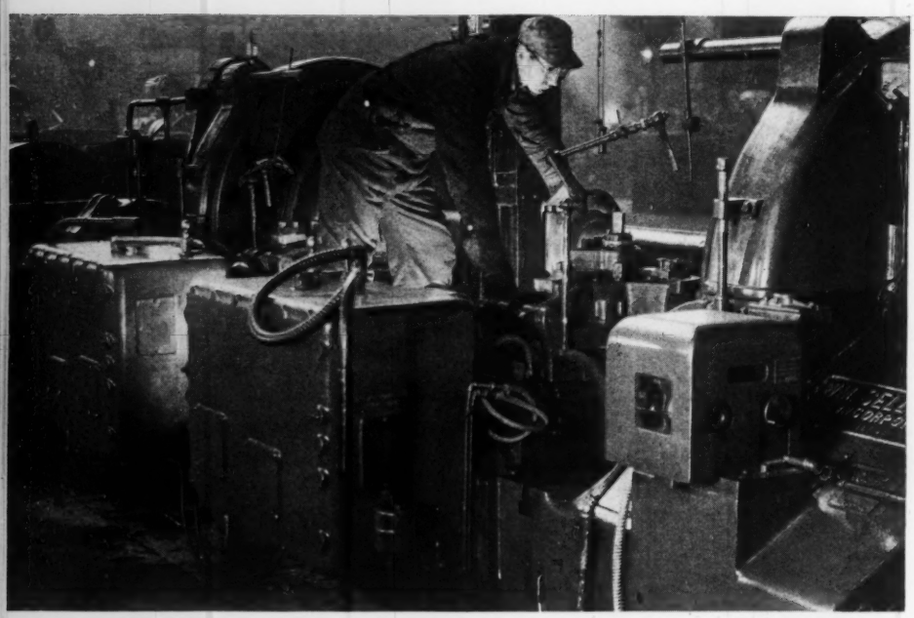
Holding the pencil in a position similar to that most commonly used in drawing, the point can be pressed against the surface of a spring balance which will indicate the pressure exerted when the point breaks or crumbles. A comparison of results will identify both the weakest and strongest leads. Lead centering, graining and strength of wood, ease of sharpening by hand or with a pencil sharpener are other items pertaining specially to wooden drawing pencils which, other characteristics being equal, may determine the final choice.

The equipment shown in *Figs.* 2 and 3 also can be used to advantage in determining certain eraser qualities. Their ability to remove ink and pencil lines from various materials can thus be measured, while any tendency to smudge or crumble excessively can be visually noted.

Fig. 2—Use of a photometer similar to that illustrated facilitates testing of drawing papers for line opacity and quality of erasures



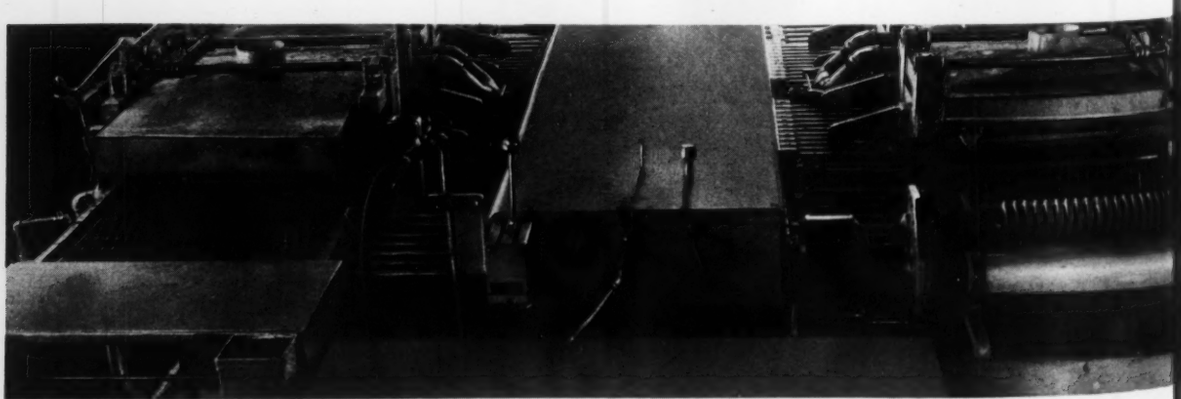
Scanning the Field FOR IDEAS

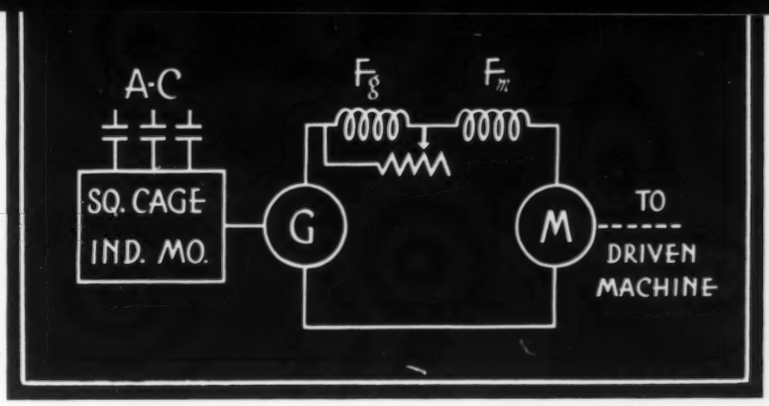


Pneumatic pilot control, employing the principle of the player piano, operates cutting tools on the Sellers' wheel turning lathe shown at left. Feed and lead of the tools are controlled by the horizontal and vertical positions of a series of punched holes in a paper strip. As the paper passes through the pilot unit, puffs of air actuate a booster unit which in turn operates each of the tools on the lathe.

In the illustration, the pilot is shown in the right foreground, with the two operating units to the left. The punched strip is made in another machine by tracing the contour of a drawing and punching the corresponding holes as required. Once a roll is made, duplicate production is automatically effected.

Plastic disks interspaced on their edges provide the solution to a conveyor problem in the felting machine designed by the Boesch Manufacturing Co. and illustrated below. Problems of felt damaged from oil or rust and of lubrication of the conveyor were solved through the utilization of the plastic disks. In process, the felt is wet. Water, therefore, is not harmful to the product and, in addition, is an ideal lubricant for plastics. For necessary strength the disks are molded with chopped duck filler.





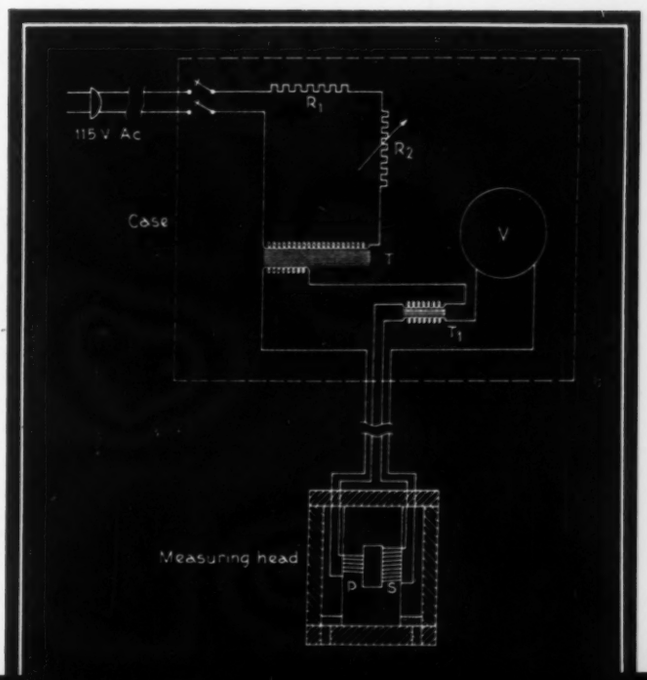
Adjustable-speed drive utilizing the series circuit at right, provides high torque characteristics and continuously variable speed range ratios to 10:1. For short time operations this range has been extended to 20:1. The circuit illustrated, developed by Westinghouse engineers, is simplified over previous arrangements in that an exciter circuit is obviated.

Three units form the circuit—a motor generator set, a series motor and a low resistance field rheostat. Principle of operation is shown by the following: When the rheostat has maximum resistance, current through the generator field is a maximum. Thus the generator voltage is maximum and the motor runs at its maximum speed. As the resistance is decreased, the generator field is weakened and the generator voltage drops, causing the motor speed to decrease proportionally.

Any tendency for a load to cause a speed change is met by a corresponding change in the field current because the fields of the motor and generator are in series, thus tending to maintain a constant speed.

Magnetic properties of a material are utilized in the thickness gage illustrated at right to measure thickness or determine a center of area. Developed by the General Electric Co., the gage measures the total flux over a fixed area of sheet material so that when the magnetic properties of a material are known, its thickness is measurable by the total flux through it.

Concentric pole structures confine the flux path to a known width. Entering the sheet through a central pole, the flux flows radially through the sheet to the outer pole which, together with a top yoke, completes the flux path. An alnico permanent magnet ring is in series with the yoke and is large enough to produce magnetic saturation. An alternating flux supplied by a transformer in the central pole becomes a function of the magnitude of the steady flux supplied by the permanent magnet and, therefore, is proportional to the thickness of the sheet.



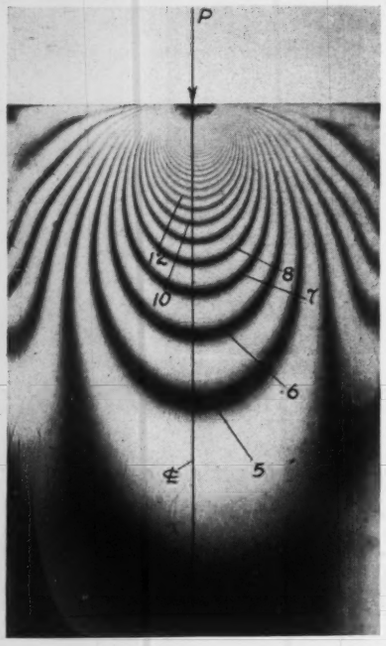


Fig. 14—Photoelastic picture of end of centrally loaded column. Enlarged 3.9 diameters, H = 86

Applying Theory of E

By R. E. Orton
Chief Engineer
Acme Steel Co., Chicago

TO MEET the stress requirements at the boundary of a beam under uniform bending, Equation 35, (Part II), the moment must be applied to the ends of the beam exactly as shown in *Fig.* 11. Moreover, the loading must be applied in such a manner as not to interfere in any way with the distortion of the end. If any departure from these conditions occur the solution will not be exact.

Similarly for the cantilever beam, Equations 38 and 39 the load *P* must be distributed over the end face exactly as shown in the shear diagram at the right in *Fig.* 13, (also Part II). Loading at the right end must balance the stresses at that end. The restraint at the right hand end must permit of the distortion which follows from this stress system.

Such requirements will rarely, if ever, be met in practice. It is apparent that something further than the theoretical development is required in order to solve a practical problem. This bridge between the theoretical loading and the actual is supplied by the "Principle of Saint-Venant." Some discussion of this important conclusion was given in a discussion on photoelasticity[1] and there it was rather loosely defined. For the purposes of advanced analysis the following more rigorous definition is required.

"If the forces acting on a small portion of the surface of an elastic body are replaced by a second system statically equivalent to the first and acting also on a small area, the stresses adjacent to the loads may be radically changed; but this change in the stress value decreases rapidly as the distance from the loaded area increases. At distances large compared with the extent of the area over which the change in load is made, the stresses will remain substantially unaltered."

[1] MACHINE DESIGN, April, 1940, Page 40.

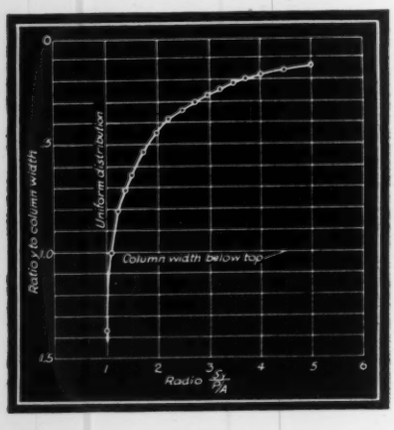


Fig. 15—Compressive stress along the centerline of a column in terms of the average

Equivalent Systems Require Scrutiny

A "statically equivalent" system is one where the summation of the moments about any point, and the summation of the forces in any direction, are the same as for the replaced system.

It must be recognized that this statement is an observation of behavior generalized from the examination of many particular cases, and is not admissible of a general proof. Its truth is tacitly assumed in elemental analysis. In the succeeding section this assumption will be investigated for a number of frequently used cases. In later articles it will be considered in many solutions of advanced analysis.

Since this essential statement must be accepted simply because it works, it must be judiciously used. Every application should be scrutinized to determine its justification. The distances from the loads at which the theoretical stress system will apply depends upon the accuracy desired, and no exact rule can be made. The cases that will be cited must serve to build up the reader's judgment.

This article will also serve to outline the limits of applicability of elemental analysis as applied to straight members. Before proceeding to this discussion some general stress relations necessary to the development will be presented.

From Mohr's diagram (*Fig.* 2, Part I), the following expressions for the principal stresses are derived

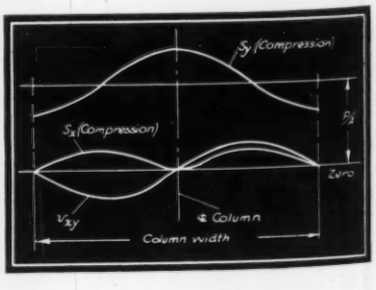


Fig. 16—Stress distribution over cross sections near the top of the column

ity in Practical Design

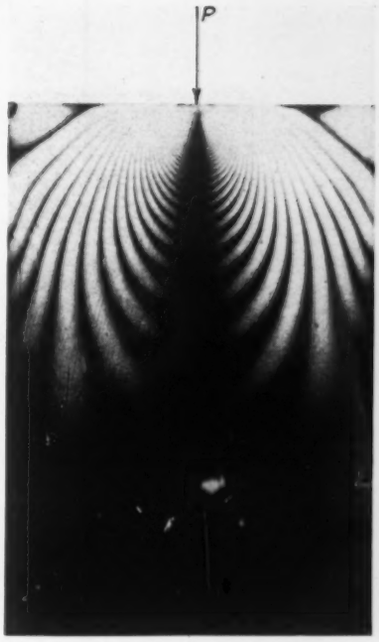


Fig. 20—Isoclinic picture of column in Fig. 14. Polarizer is set vertical. Enlarged 3.9 diameters

Part III

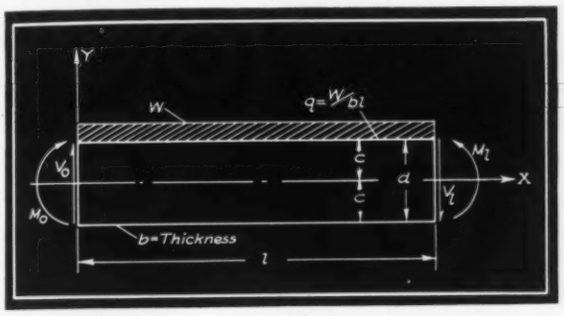


Fig. 17—General case of bending under a uniform load distributed over entire length

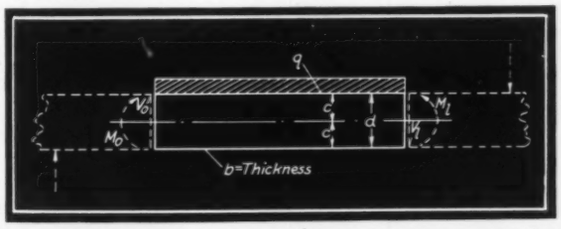


Fig. 18—General case of bending under a partially distributed uniform load

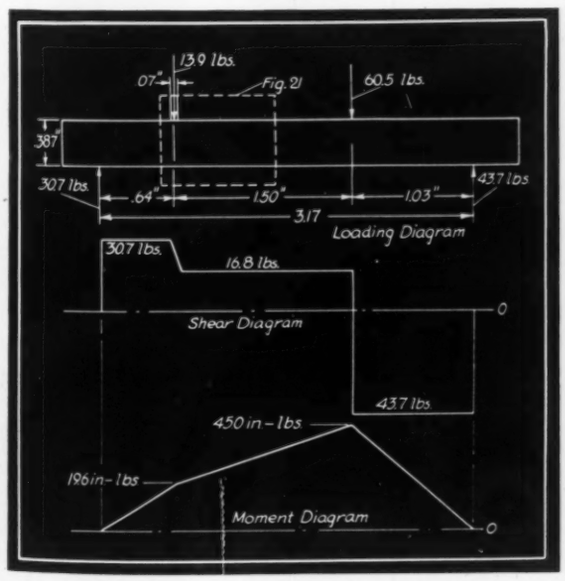


Fig. 19—Loading of model for photoelastic picture as illustrated in Fig. 21

$$S_1+S_2=S_x+S_y \quad \ldots\ldots (40)$$

$$S_1-S_2=2\sqrt{\left(\frac{S_x-S_y}{2}\right)^2+(v_{xy})^2} \quad \ldots\ldots (41)$$

first adding the above and then subtracting

$$S_1=\frac{1}{2}(S_x+S_y)+\sqrt{\left(\frac{S_x-S_y}{2}\right)^2+(v_{xy})^2} \quad \ldots\ldots (42)$$

$$S_2=\frac{1}{2}(S_x+S_y)-\sqrt{\left(\frac{S_x-S_y}{2}\right)^2+(v_{xy})^2} \quad \ldots\ldots (43)$$

and again from the figure directly

$$tan\ 2\alpha=\frac{2v_{xy}}{(S_x-S_y)} \quad \ldots\ldots (44)$$

Rankines formulae for "combined normal stress and shear," given in the usual work on Strength of Materials will be recognized as the special case of Equations 42 and 43 where $S_y = 0$,

$$S_1=\frac{1}{2}S_x+\sqrt{\frac{1}{4}S_x^2+(v_{xy})^2}\ ;\ S_y=0$$

$$S_2=\frac{1}{2}S_x-\sqrt{\frac{1}{4}S_x^2+(v_{xy})^2}\ ;\ S_y=0$$

In photoelastic analysis, the principal stress dif-

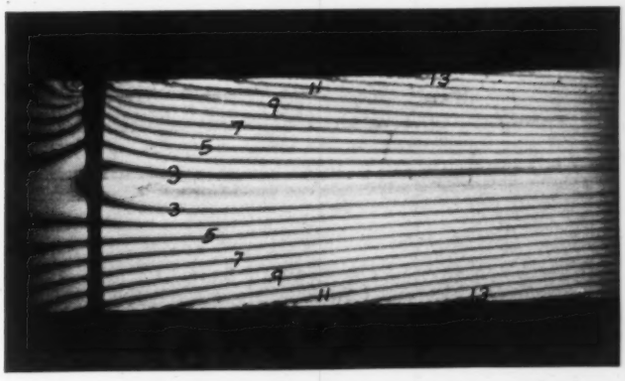


Fig. 21—Photoelastic picture of beam in Fig. 20. Enlarged 5 diameters, H=86.6

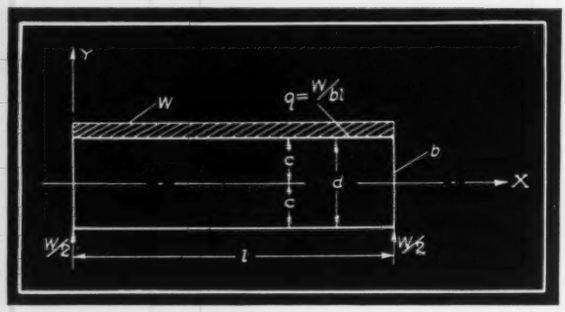


Fig. 22—Simple beam with uniformly distributed load

ference, $S_1 - S_2$, noted as Q, is measured. From Equation 41 then, the following general expression for the fringe order n in terms of stress is derived

$$n = \frac{Qb}{H} = \frac{b}{H}(S_1 - S_2) = \frac{b}{H}\sqrt{(S_x - S_y)^2 + 4(v_{xy})^2} \quad (45)$$

where H is the calibration value of the material[2].

Analysis of Straight Members

The greater portion of elemental analysis for plane stress may be considered as built up on three basic stress systems:

1. Direct stress distribution.
2. Bending stress distribution.
3. Shear stress distribution.

The usual problem is solved using these systems alone or in combination.

For other than straight members these distributions are generally in error, the extent of the error depending upon the curvature or other alteration in the shape. The distribution in such shapes will be examined in later articles. The purpose of this section is to examine, by elastic theory, these basic systems as applied to straight members.

Typical of system 1 is a column centrally loaded with a concentrated load P. Elementary theory assumes that the stress is uniformly distributed, and is given by P/A where A is the cross section area.

[2] MACHINE DESIGN, May, 1940, Equation 19.
[3] "Theory of Elasticity," McGraw-Hill, Pages 49 to 51.

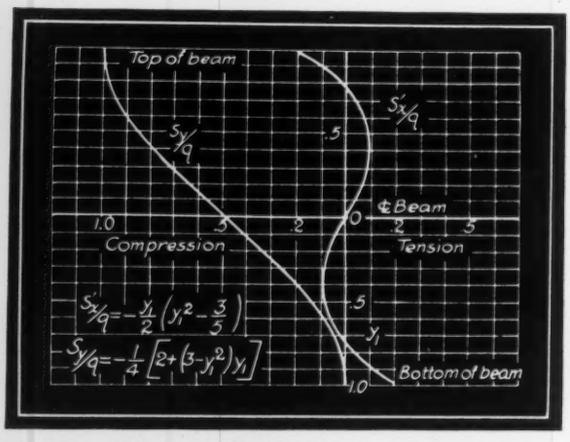


Fig. 23—Additions to elemental stress system to obtain true stress. General bending under uniform load is shown in Figs. 18 and 22

This assumption is admittedly correct at sufficient distances away from the load. The question is how far away, and what is the distribution close to the load?

It should be recognized that a concentrated load is only a theoretical consideration. Practically no load is concentrated but is distributed over some area, although this area may be very small. By means of the contact stress equations of Hertz, to be developed in a later article, this loaded area may be determined for any given method of applying the load, and the load distribution over this area found. From this it may be seen that the distribution problem of the stress in this column may be divided into three regions. The first region, immediately adjacent to the application of the load, where the Hertz equations permit the determination of the actual load distribution, and from this the stress in the immediate vicinity of the load. The third region which assumes a uniform distribution of the stress; and the second which serves as the bridge between the first and the third and which is here presented.

Considerable mathematical investigation of this

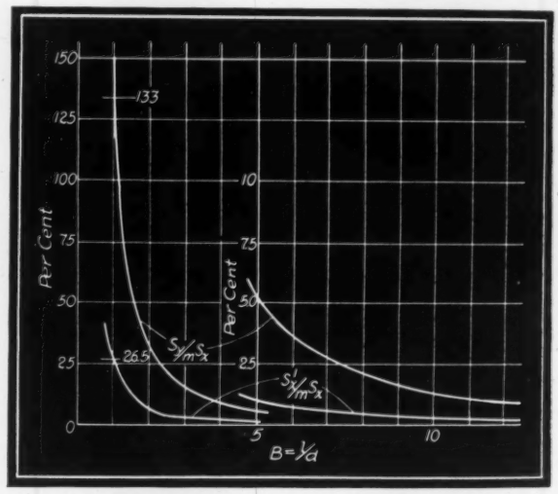


Fig. 24—Stress correction for top surface of uniformly loaded simple beam in Fig. 22

problem is reported by Timoshenko[3]. This analysis is based on using a finite number of terms of an infinite trigonometric series (Fourier series), and by another approximation in regard to the stress perpendicular to the column axis. Because of the considerable amount of work involved in this investigation, it will not be presented here. Instead the distribution will be studied photoelastically.

Fig. 14 is a photograph of the fringe pattern of the upper portion of the column. *Fig.* 20 is an isoclinic pattern (obtained with plane polarized light) of this same column loaded as before. Analyzer is set vertically.

If elemental theory is correct, the principal directions will be parallel and perpendicular to the center line of the column. Therefore $v_{xy} = 0$. The principal stress perpendicular to the center line will also be zero leaving only the vertical normal stress. This

will result in a uniform fringe value throughout the member. *Fig.* 14 shows the fringe value constant over the cross section at a little more than the width of the column below the top. The level is 4 in this case. In *Fig.* 20 the load was increased half an order giving a light band in place of the dark in *Fig.* 14. This was done in order that the isoclinics would not be blanketed by the fringe pattern. Note that the picture is entirely black at the width of the column below the top. From this we may conclude that, for a column centrally loaded with a concentrated load, elemental theory is substantially correct at a distance

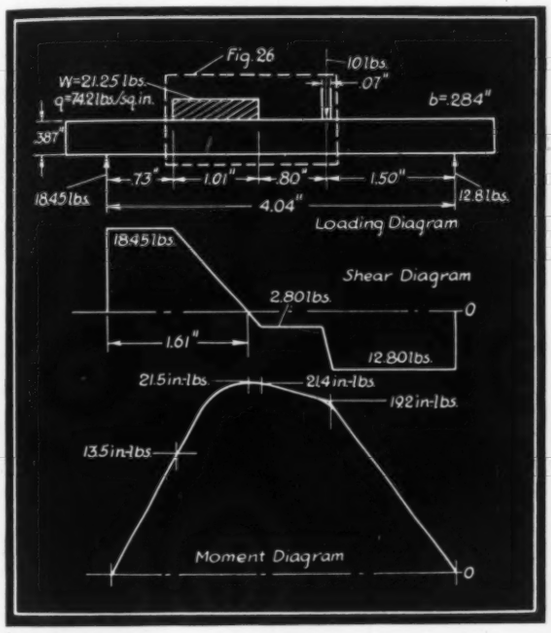


Fig. 25—Loading of model for photoelastic picture illustrated in Fig. 26

away from the load equal to the width of the column.

Also in *Fig.* 20 is shown the principal directions vertical and horizontal along the centerline of the column to the loaded face. As will be brought out in a later article, we may conclude that the horizontal direct stress is zero close to the upper face and differs by little, if any, from zero along the entire center line. Also v_{xy} must be equal to zero along the entire center line. On this basis the fringe value along the center line of the column will determine the direct stress. With this information and the photoelastic picture, *Fig.* 15 is constructed to indicate this center line stress. As shown, at the width of the column

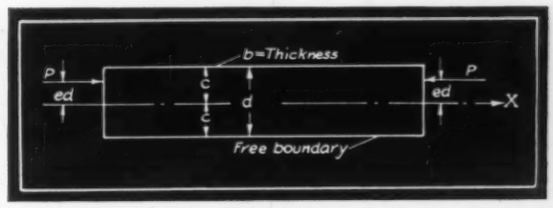


Fig. 27—Eccentrically loaded column

below the top, the stress is about 10 per cent greater at the center than the average, and at ½ the width, about 75 per cent greater. At ¼ the width it is 3 times the average and the increase is rapid above this point.

Bending Under Uniform Load

Because of its interest at this place, *Fig.* 16 is also presented. This figure gives a qualitative picture of the stress distribution across the face of the column in this intermediate region. A discussion of the development belongs with the later article previously mentioned.

System 2 is the general case of bending of straight members under transverse loads and system 3 the "vertical" shear stress, v_{xy}, distribution. These may be developed from the stress function

$$\phi_4 = A_4y^5 + B_4y^3 + C_4xy^3 + D_4x^2y^3 + E_4xy + F_4x^2y + G_4x^3$$

Substitution of this in the compatibility relation of Equation 34 shows that it will be satisfied provided that

$$5A_4 + D_4 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (46)$$

Substitution of ϕ_4 in Equation 33 gives for the stresses connected with this function

$$S_x = \frac{\partial^2\phi_4}{\partial y^2} = 20A_4y^3 + 6B_4y + 6C_4xy + 6D_4x^2y$$

$$S_y = \frac{\partial^2\phi_4}{\partial x^2} = 2D_4y^3 + 2F_4y + 2G_4$$

$$v_{xy} = -\frac{\partial^2\phi_4}{\partial x\partial y} = -(3C_4y^2 + 6D_4xy^2 + E_4 + 2F_4x)$$

The general case of bending under a uniform load is illustrated in *Fig.* 17. It consists of a beam of rectangular section with parallel boundaries. A uni-

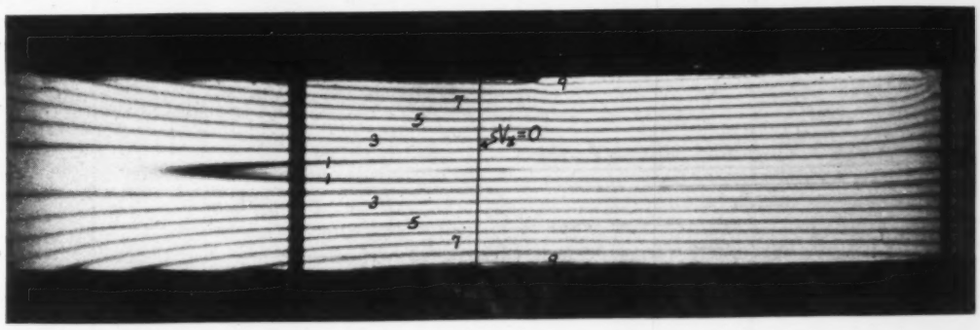


Fig. 26—Photoelastic picture of beam in Fig. 25. Enlarged 5 diameters, H=86.6

formly distributed load of W pounds applied along the upper boundary produces a pressure of q pounds per square inch, where $q = W/bl$. The external moment M_0 applied to the left end is balanced by the horizontal normal stresses S_x at that end, the summation of the moment of which must therefore equal M_0. The horizontal summation of S_x must also equal zero. Similarly the external total shear V_0 must be balanced by the summation of the shear stresses on that face. The loads on the right hand end may not be arbitrarily assumed but must balance all the other loads. By summation of the external moments and forces then

$$V_l = V_0 - W \quad \ldots\ldots (47)$$

$$M_l = M_0 + V_0 l - \frac{1}{2} Wl \quad \ldots\ldots (48)$$

The stresses on this end must balance these loads.

The above boundary conditions may be stated mathematically as follows,

A. When $y = +c$; $S_y = -q$; $v_{xy} = 0$

B. When $y = -c$; $S_y = 0$; $v_{xy} = 0$

C. When $x = 0$; $\int_{-c}^{c} S_x b\,dy = 0$

$$\int_{-c}^{c} S_x y b\,dy = -M_0$$

$$\int_{-c}^{c} v_{xy} b\,dy = -V_0$$

D. When $x = l$; $\int_{-c}^{c} S_x b\,dy = 0$

$$\int_{-c}^{+c} S_x y b\,dy = -M_l$$

$$\int_{-c}^{+c} v_{xy} b\,dy = -V_l$$

Substitution of the values of S_x, S_y, and v_{xy} in the above, together with Equations 46, 47 and 48 will determine the constants. Substitution of these values of the constants, in the stress equations gives

$$S_x = -\frac{6y_1}{bd^2}\left(M_0 + V_0 x - \frac{1}{2} bqx^2\right) - \frac{q}{2}\left(y_1^2 - \frac{3}{5}\right) y_1 \quad (49)$$

$$S_y = -\frac{q}{4}\left[2 + (3 - y_1^2) y_1\right] \quad \ldots\ldots (50)$$

$$v_{xy} = -\frac{3(V_0 - bqx)}{2bd}\left(1 - y_1^2\right) \quad \ldots\ldots (51)$$

Now if M_x is the moment and V_x the shear on any section

$$M_x = M_0 + V_0 x - \frac{1}{2} bqx^2$$

$$V_x = V_0 - bqx$$

Substituting in Equation 49, 50, and 51

$$S_x = -\frac{6M_x y_1}{bd^2} - \frac{q}{2}\left(y_1^2 - \frac{3}{5}\right) y_1 \quad \ldots\ldots (52)$$

$$S_y = -\frac{q}{4}\left[2 + (3 - y_1^2) y_1\right] \quad \ldots\ldots (53)$$

$$v_{xy} = -\frac{3V_x}{2bd}\left(1 - y_1^2\right) \quad \ldots\ldots (54)$$

Fig. 17 may now be considered as a portion of a beam as shown in *Fig.* 18 where M_0, V_0, M_l, and V_l are produced by the adjoining portions. While the stresses on the two sections at the junctions may not even approximate the system of Equations 49, 50 and 51, the *resultant* moment and shear will be equal to M_0, etc. Therefore the true stress distribution is "statically equivalent" to the above. By Saint-Venant's principle, then Equations 52, 53 and 54 will approximate the true distribution at sections away from these load end sections. Critical sections will occur, however, wherever there is a discontinuity of load, or the beam ends are reached.

Before discussing the significance of these general equations several special cases derived from them will be considered. The stress distribution under a free boundary is obtained by substituting $q = 0$,

$$S_x = -\frac{6M_x y_1}{bd^2} = -\frac{M_x y}{I} \quad \ldots\ldots (55)$$

$$S_y = 0 \quad \ldots\ldots (56)$$

$$v_{xy} = -\frac{3V_x}{2bd}(1 - y_1^2) = -\frac{V_x}{2I}\left(c^2 - y^2\right) \quad \ldots\ldots (57)$$

The last expressions for S_x and v_{xy} are obtained by substituting $I = bd^3/12$. These expressions are in exact accord with elemental theory, S_x having a linear distribution and v_{xy} a parabolic. The normal stress is zero at the center and a maximum at the top and bottom surface where it equals $\mp M_y c/I$, the shear stress is zero at the top and bottom and a maximum at the center where it equals $-3V_x/2bd$, (50 per cent more than the average). From this it is apparent that elemental theory is exact at all sections of a beam sufficiently removed from any load.

Substituting these stress relations in Equation 45 gives for the photoelastic fringe value

$$n = \frac{6}{Hd^2}\sqrt{M_x^2 y_1^2 + \frac{1}{4} V_x^2 d^2 (1 - y_1^2)^2} \quad \ldots\ldots (58)$$

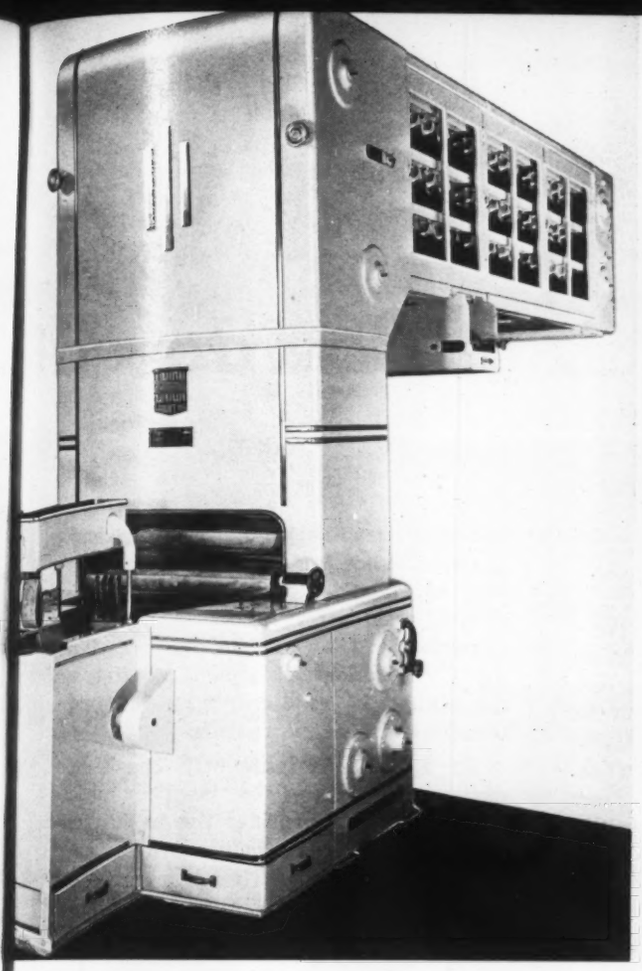
Fig. 21 is a photoelastic picture of portion of the beam shown in the loading diagram of *Fig.* 19. This photograph together with Equation 58 will be discussed as an illustration of Saint-Venant's principle.

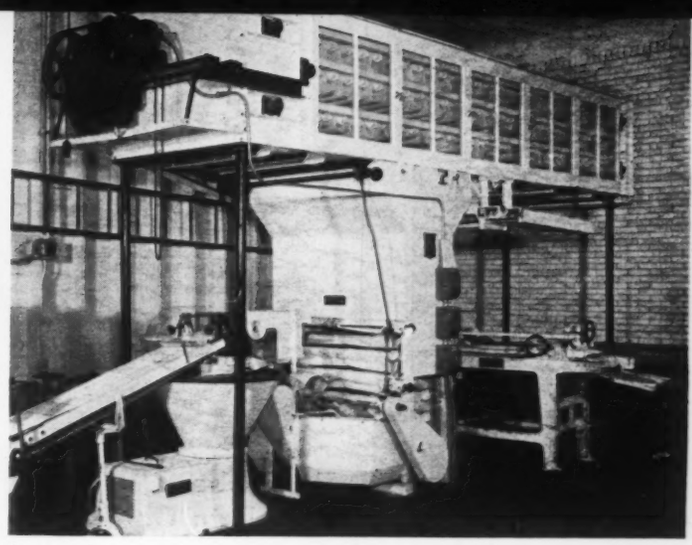
At the center line $y_1 = 0$ which gives for the fringe value

$$n = \frac{3V_x}{Hd} = .0895\, V_x = 1.5 \text{ between the loads}$$

The band along the center line is a double fringe

(*Continued on Page* 78)





Cleanlining Pays Big Dividends

FREQUENTLY remarkable improvements in machines can be effected by relatively simple changes in styling and arrangement. Two excellent examples in bakery machinery are furnished by the new proofer and rounder designed by Union Machinery Co. The "before-and-after" photographs shown on this page illustrate the extent to which redesign improves appearance. Proofer views are at the top, with the old and new rounders at the left.

Reference to the new proofer shows how the motor drive and variable speed unit have been removed from the upper front panel and placed out of the way on the base of machine. Auxiliary drive sprockets and chains for the sifters and conveyor, which previously required unsightly, protruding guards, also have been moved into the base. Compactness thus has been gained, along with vastly improved appearance and cleanliness. Yet mechanisms are still readily accessible.

Finish Accentuates Smooth Contours

Wherever possible, all plane surfaces of the welded steel frame have been rounded. Surfaces are spray coated with durable white enamel, excellent for bakery machinery. Strips of chromium on large enameled surfaces are decorative and accentuate the angular simplicity. The upper front panel, for instance, would present a displeasing blank area except for the three chromium strips.

Similar principles were employed in the "cleanlining" the dough rounder, with an interesting variation. Decorative ribs are cast in the front of the base and the motor housing, and are trimmed with chromium paint. Motor louvres have the same treatment.

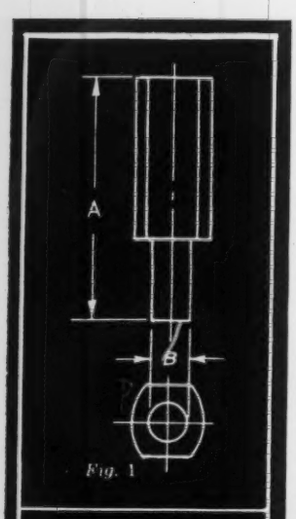


Fig. 1

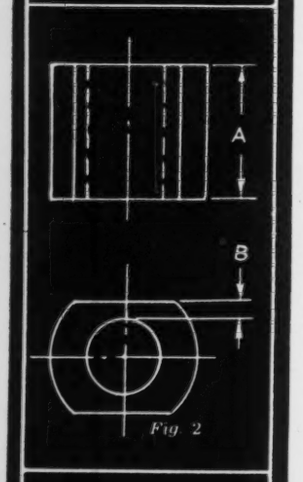


Fig. 2

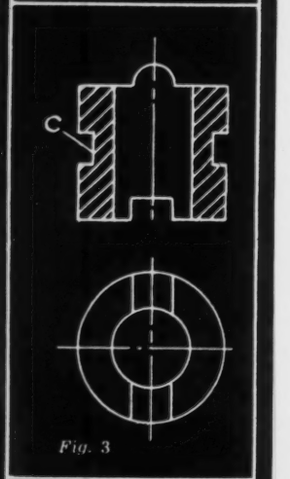


Fig. 3

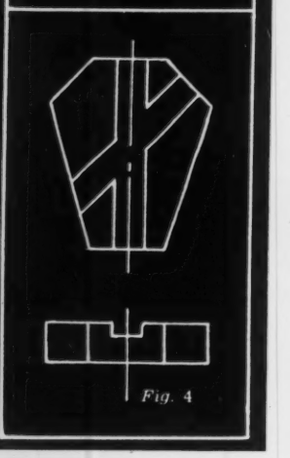


Fig. 4

Designing Powdered

By Richard P. Seelig and Eric C. Gordon

Powder Metallurgy Inc.

MACHINE parts of sintered powdered metals afford, in addition to the advantage of being capable of production to finished dimensions, a whole new set of controllable combinations of physical properties. However, only the surface has been scratched in exploring the possibilities of this new technique, primarily because the rules for applying it consist principally of exceptions. Thus, what may be true concerning a part of one material may not be true if another is used, because of factors such as differences in flow of powders or in compressibility of materials. Moreover, an economical part in one material may be costly in another. For instance, the saving in a shape made by powder metallurgy from an age-hardening aluminum alloy might be completely eliminated if the part were made of a free-machining material.

This article is intended to indicate to the machine designer the shapes and proportions of machine parts which readily may be made by powder metallurgy and how to decide what parts should be so made. Widely used powder metal parts such as cemented carbides, refractory metals, porous bearings and electrical contacts and magnets will not be discussed; only machine parts outside these established fields will be covered.

Eliminates Expensive Machining

Reasons for using powder metallurgy can be summarized as: (1) Unique materials possessing widely varied physical properties can be produced to be fabricated subsequently by conventional methods, including rolling, swaging, drawing, brazing, welding, machining, etc. Although these possibilities are manifold, they should be discussed from a metallurgical point of view; (2) finished articles which cannot be economically or readily produced by conventional fabricating methods are often easy to make to tolerance from metals, alloys and metal-nonmetal combinations; and (3) semifinished machine parts on which subsequent drilling or machining is required may eliminate usual expensive operations.

To appraise intelligently the shape design possibilities of powder metallurgy one must consider the basic technique in the manufacture of pressed and sintered parts. First it must be determined whether a material suitable for the purpose can be produced by known powder metallurgy practice. Generalizing, it can be said that bronze and brass parts made from powders may have as good or better physical properties than the same parts made by casting.

Properties Largely Unexplored

In at least some properties they can be made equal or superior to those of wrought metal. In the range of ferrous materials, the field is newer than that of brass or bronze. If price were no object, the physical properties obtainable could be excellent, but for the moment it can only be said that ferrous powder metallurgy parts can be made equal to or better than cast iron or low carbon steel. However, in impact or shock value the materials are not as good as wrought metal. Even less has been done in research and development of other alloys such as aluminum and nickel. Usable parts can be made from them but not even a generalized statement can be given of the comparative properties obtainable.

Dies predominantly control shape and fundamentally must be capable of withstanding the high pressures, i. e., 40,000 to 400,000 pounds per square inch, which are needed to obtain satisfactory results. Since metal powders have poor flow, the die must permit uniform pressure on all parts of the piece and also must permit ejection after pressing. So-

Machine Parts

called split dies are generally uneconomical. Dies are generally designed to operate only vertically and thus undercuts and cross holes must be avoided even to a greater degree than in die casting. Some materials shrink and others expand during the sintering operation so that allowance must be made in the die accordingly.

The sintering operation is usually a costly one. Heat cost increases with bulk of material and economy is apt to be substantially reduced with increased part size unless a special material is being produced.

Part Size Determines Tolerances

It should be borne in mind that what may be said concerning shape possibilities may be feasible in some powder metallurgy materials and not in others. This is also true in the case of the tolerances to which powder metallurgy parts can be made. Because of shrinkage or expansion in the sintering operation, the percentage of error becomes greater as the size of the part increases. Thus, although one can say generally that powder metallurgy parts can be held to plus or minus .001 to .005-inch, if the part weighs two or three pounds this will probably not be true except in certain materials. But if the part weighs less than ¼-pound better tolerances can be expected, particularly if the parts, after being pressed and sintered, are coined or sized. Closer radial tolerances can be expected than axial tolerances. In other words, the dimensions vertically in the pressing die, where the die must open and close, cannot be held as accurately as the dimensions radially which are completely surrounded by the die.

The following examples will serve as a criterion of the shapes and proportions of machine parts which lend themselves to being formed of powdered metal. A careful study of the diagrams will serve to outline to the designer the shape possibilities and limitations of the process. Throughout it must be borne in mind that what is said concerning one part, usually applies to all the others. Particular points will not be repeated, but discussion will be limited to the new factors which each part presents.

Fig. 1 shows a ferrous cam which can be easily made. However, its length *A* must not be too great in relation to the area at its diameter *B*. No definite rule can be set forth as to what this relationship should be. On the part in question a rule of thumb may be used. Where high density is wanted, *A* should not be more than three times *B* if the part is to be made of brass or bronze, twice if of a ferrous composition, and the same dimension in most other materials. If density is not essential or porosity not important, these proportions might be substantially increased, but even then there is an ultimate height limitation. In all cases, as the size of the part increases its cost increases; as it becomes more complex it becomes more expensive.

Taper Simplifies Ejection

Another easily made cam is in *Fig.* 2. The hole may be either straight or tapered; in fact a slight taper simplifies the problem since ejection is made easier. The hole reduces the pressing area and consequently the proportionate height *A* allowable is not as great. Wall thickness at *B* must not be too small since in pressing, the powders would tend to compact sooner at that point because of their poor flow. Hence the density would not be uniform throughout the piece.

Fig. 3 illustrates an end projection which can be incorporated without substantial increase in cost unless the projections were very high or very deep. The undercut *C* would of course have to be subsequently machined.

Fig. 4 is a simple shape particu-

Fig. 5 Fig. 6 Fig. 7 Fig. 8

larly suitable for powder metallurgy, provided the area is not too great for the available press. If the area of the piece were three square inches and required 40 tons per square inch, a 150-ton press would be needed. The overall thickness shown is eminently satisfactory. However, were it .01-inch, the part would probably not be feasible even if it did not have the grooves, since the green strength (before sintering) would not permit handling. Grooves cannot be too deep for the same reason. A decided advantage is offered by powder metallurgy in parts such as this, since the outside contours can be fairly complicated without introducing undue molding difficulties.

Changes in Section Undesirable

The part in *Fig.* 5 could not be made of a hard material by stamping, and yet it could easily be made by powder metallurgy. Caution must be exercised in making parts such as this in two particulars. First, the wall of the hole *B* must not be made too thin since the die core needed would be too weak and it might be difficult to hold the location of the hole accurately. It is usually cheaper to drill the small holes later than to complicate the die with the very fine core rods which would be needed. The second problem is the depth of the depression at *A*. Radical and numerous changes in thickness create a problem of uniform density and ejection, because prior to compression the powders must be held in the die and, uncompressed, their volume is several times that of the pressed piece. Thus, complicated dies and presses would be needed to control the fill accurately.

Fig. 6 merely shows a bevel on an axis which must be held to close tolerance. The difficulties of conventional methods are avoided by powder metallurgy. However, if the bevel were too great the male punch of the die might not be able to be made sufficiently strong.

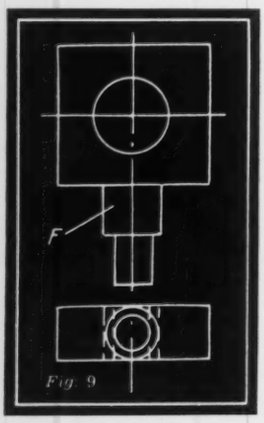


Fig. 9

Use of powder metallurgy for complicated parts such as those following is just developing. Experience alone will show to what extent these complicated parts will compete with present methods. A combination of the factors indicated in *Figs.* 2 and 5 is shown in *Fig.* 7. Here the elimination of the broaching of the center hole alone more than justifies the use of powder metallurgy. A part such as this was formerly made of bronze because when made of steel the broach broke in production. By powder metallurgy the part can be made of either bronze or of a ferrous composition without substantial additional fabricating cost of the latter over the former. The flange *B* must not be too small in relation to the overall height *A* if, at the same time, the wall at *C* is thin. By reducing the difference between *A* and *B* or increasing the wall thickness, or both, the part becomes quite suitable. The undercut would have to be machined afterward.

A more complicated variation of the same theme is in *Fig.* 8. The distance at *D* must not be great, because then the problems of fill and ejection make the cost unwarranted.

Fig. 9 is a combination of the primary shapes of *Figs.* 1 and 4. Because of the increased complexity, the pressing would have to be in the direction indicated by the arrow. Since round shapes must be pressed vertically, the arm would have to be changed as indicated by the dotted lines. If it is essential that it be round it would have to be machined off afterward on a lathe.

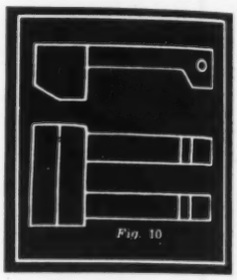


Fig. 10

Numerous advantages are presented by *Fig.* 7, which can be produced to finish without machining except for the buffing of the bevel, and drilling and reaming of the hole. Operations in its production involve two pressing operations with separate dies and sintering. Conventionally such a part would be forged after heating, the burrs sheared, the slot milled and the other surfaces milled to tolerance, and then the bevel buffed and the hole drilled and reamed. The resulting mechanical strength of the powder metal part is sufficient in operation although not equal to its forged predecessor, but it wears better on the bevel where constant friction occurs.

In considering what parts may be suitable for powder metallurgy manufacture, one must not look solely to the material presently used, although that acts as an excellent guide. It must be determined to what use the part is put and what properties are ultimately required.

Technique Is Constantly Advancing

It can be seen that within the obvious limitations created by the manufacturing equipment needed almost any kind of a shape can be made by powder metallurgy. A multitude of materials are now available. In the use of each the factors of cost and quality must be weighed to determine whether powder metallurgy is a proper or economic mode of manufacture.

The designer should keep in mind that the cost of metal powders is substantially greater than the cost of ingot metal and that the process is generally a more expensive one than die casting where no subsequent machining is needed; than stamping and than straight screw machine operations. Only occasionally does powder metallurgy material offer such improved quality over cast metal as to warrant a higher price.

Fortunately, there are constantly improved powders on the market and the technique of powder metallurgy practice is constantly advancing. When more correlated research is done to determine why powder metallurgy works, how it is best worked and what physical properties each material and alloy has, then only can a ready reference table be prepared.

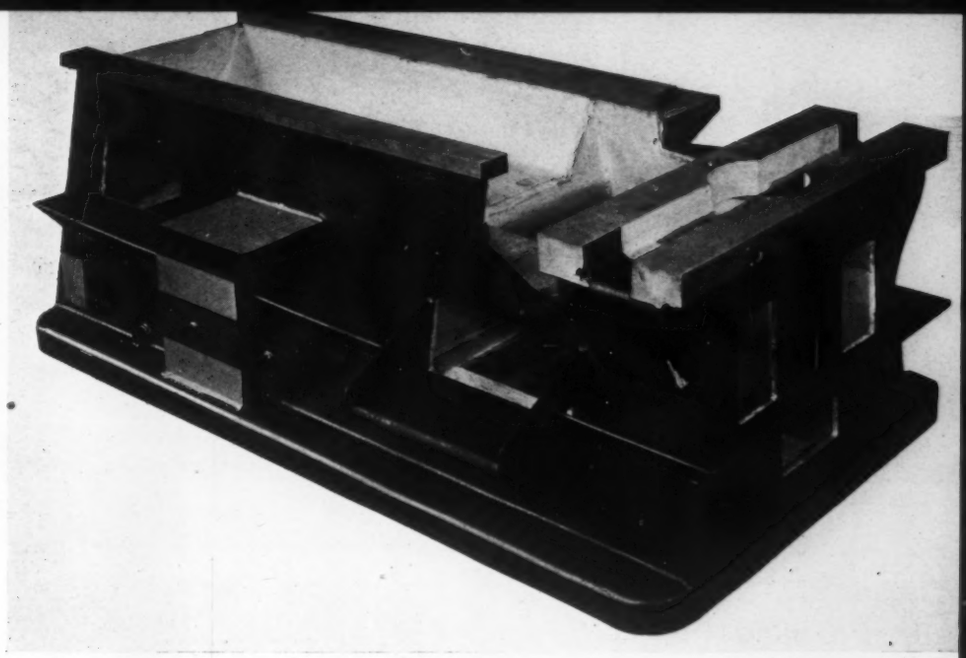


Fig. 1—Finished bed of Stamets pipe threading machine incorporates strength and rigidity compatible with light weight and attractive appearance

By Roger B. White
Lewis Welding & Engineering Corp.

How and Where To Use Welded Fabrication

FABRICATED steel construction in the design of machines is increasing rapidly with an expanding knowledge of its advantages and confidence in its use. Only a thorough acquaintance with the possibilities and limitations of this technique, however, will enable the engineer to know best where and how to apply it.

It is important that the designer should understand the requirements for economical fabrication by welding. Otherwise a design often progresses too far to be adapted to efficient welding procedure without considerable disturbance of the design itself. Further, complete knowledge of the process may disclose, at the outset of a design, that it is not the best selection among the processes available.

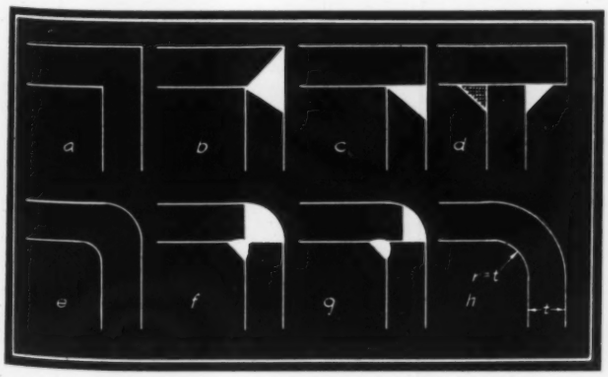


Fig. 2—Proper design of corners is essential in obtaining economical and accurate machine structures

Choice of the most suitable process usually can be made on the basis of a direct cost comparison plus several other important factors. The design engineer should be familiar with the following factors as well as those influencing direct cost.

Widespread adoption of fabricated construction has probably been retarded more by the general belief that fabricated parts are always clumsy looking than by any other single factor. This belief is erroneous. Approach to the problem of a welded design unbiased by preconceptions resulting from familiarity with other fabricating methods is essential. Production of a piece which will function properly and at the same time provide the desired "eye appeal" should be the primary aims.

Weight reduction is another factor in considering the use of welding, particularly for any piece of mobile equipment. Some machinery requires weight for stability and in such cases castings may prove more satisfactory. However, most machines will not suffer from a reduction in weight provided this is accomplished without sacrifice of rigidity. In fact lighter machines are easier to handle and less subject either to accidental damage during manufacture or in subsequent installation or relocation in users' plants.

Progressive construction of fabricated parts affords certain production advantages. For example, water or oiltight parts may be tested when only partially

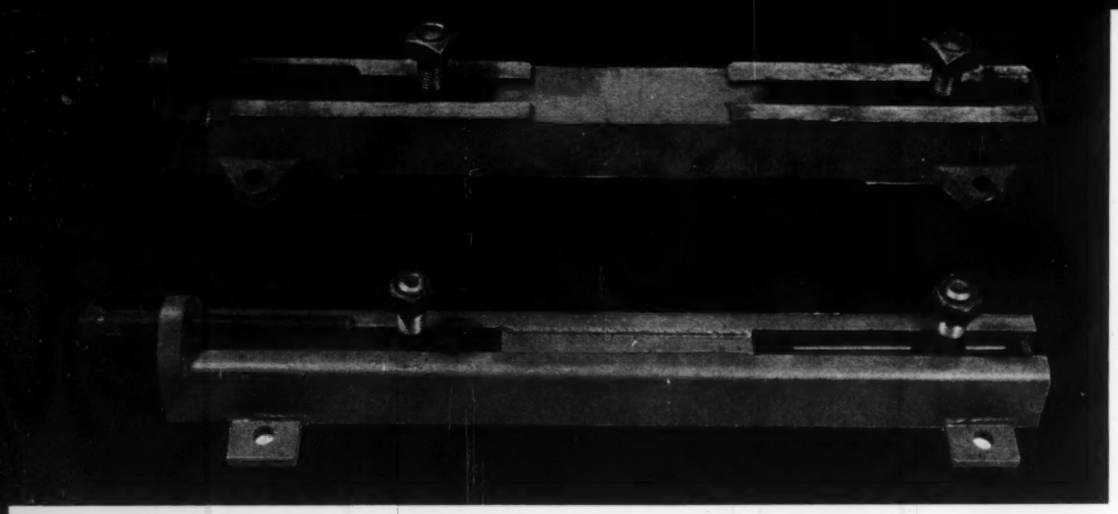


Fig. 3—Cast and welded machine slide rails indicate the comparison between the two methods of fabrication

completed in order to give better access for inspection. Also, dimensional errors that may occur in an important finished part can readily be corrected.

Hand in hand with the reduced weight usually found in weldings goes increased strength. This results, in part, from the higher physical properties of rolled steel and in part from the factors of uniformity and homogeneity of the material used.

Properly designed steel weldings will be at least as rigid as iron castings because the modulus of elasticity of steel is practically double that of iron. Careful design is important at this point, however, because design for economical fabrication may tend to produce long unsupported surfaces. This condition combined with reduced wall sections may result in structures which spring excessively under load. Proper reinforcing and support will avoid this difficulty. Rigidity or stiffness often becomes a deciding factor in favor of iron where pieces are small and a steel section of equivalent strength would be too flimsy, or a steel section of equivalent stiffness too expensive.

Diaphragms Obviate Excess Vibration

Another property somewhat akin to rigidity is resistance to vibration. This is not the same as rigidity since a part may be sufficiently rigid under static load but not under vibrating load. Cast iron will dampen and absorb such vibration to a greater extent than steel and greater care must be taken in designing welded structures subject to this type of load. Proper arrangement of diaphragms will usually obviate this trouble.

In addition to the foregoing considerations the direct cost economies usually attainable with fabricated steel construction result from a number of factors, all of which should be taken into account in determining the most economical construction for a given part.

In some cases a welding will cost less on a direct price per pound basis. This will be found in the case of very simple pieces on which only a relatively small amount of work is required, or on pieces which, if cast, would require difficult core work. Obviously, though, a direct price comparison is not sufficient. Savings will be found in the elimination of pattern costs including maintenance, storage, and replacement. Also, since no patterns are required, minor changes in design can be effected at little expense.

Properly designed weldings frequently require little machine work since the smooth surface of the rolled steel plate will often be satisfactory as a matching surface without further finishing. In some cases machining can be done on small pieces before welding and thus eliminate handling of a larger heavier piece, permitting use of a lower rate machine. Frequently pieces which are made separately as castings can be combined into a single welding, thus saving the machining and bolting necessary to tie them together. Direct machining time will also be affected because the rolled steel plates used in welded machine parts machine faster and easier than steel castings. Gray iron castings, on the other hand, usually machine easier than steel weldings. However, it is frequently possible to provide closer tolerances in weldings with consequent reduction in metal to be removed in machining.

It is widely recognized that fabrication from steel plate, where only a few pieces are required, is likely to be found cheaper than casting because the pattern cost is eliminated. In addition, there are many parts required in large quantities where the cost of a fabricated piece can be made less than the direct cost of the casting without regard to pattern expense. These latter frequently require careful engineering analysis to produce a satisfactory fabricated design, but they are much more important since the savings continue as long as the piece is made.

Amount of Cutting Influences Cost

Jigs and fixtures can be built to facilitate assembly of pieces to be welded. Accurate dimensional tolerances obtainable with proper fixtures will sometimes permit elimination of machined surfaces. Due to cumulative inaccuracies in making pieces required for an assembly, the individual pieces from which a welding is made seldom go together easily the first time a piece is built. Repetition permits these errors to be corrected at their source.

Typical examples of economical quantity production pieces varying widely in size are shown in *Figs.* 1 and 3. Good appearance has not been sacrificed in designing these pieces for welding.

Inasmuch as the fabricator receives his plate in large rectangular flat pieces, the cost of the finished welding is entirely a function of the amount of work which must be done on these pieces in converting them into finished parts. If they must be cut into many small pieces the cost will be increased due to the time required for cutting and fitting them together,

for welding them in place, and for cleaning or grinding after welding.

Designs should be kept as straightforward as possible. Offsets, bosses, holes, gussets, notches, and similar irregularities are expensive and should be avoided or simplified. Frequently an offset surface can be straightened out simply by changing the support pads under it. Small bosses may be simplified by combining them into one pad. The smooth surface of rolled steel plate is quite satisfactory as a bolting surface in many cases. It should not be depended upon where a gasket seal is required unless thick gaskets made from a soft material such as rubber or rubber-like materials are used.

Irregular holes should be avoided where they serve no functional purpose. Such holes are not objectionable in castings because they reduce weight and provide core supports but in a welding it may cost just as much to remove this material as is saved by coring the casting. Gussets and stiffeners should be added to weldings only where essential. Frequently a somewhat heavier section can be used without gussets at a lower cost. Gussets, bosses, and pads, when used, should be located on the inside wherever possible since this eliminates the necessity for careful rounding of corners and generally contributes to clean, trim appearance.

Proper design of corners is an important factor in producing economical weldings. *Fig.* 2 illustrates a variety of corner designs. Note that *h*, a simple bend, is the most trouble-free, best looking and often cheapest. The double scarfed joint shown at *b* is undesirable because the slim outside corner is likely to be melted during welding with consequent irregularity. Furthermore this design requires two scarfing operations instead of one as in *c*. Wherever appearance is not an important factor and the design will allow, the offset construction shown in *d* should be used. This is the easiest to fit together since neither the appearance nor the final dimensions will be affected by slight variations in the pieces and no scarfing preparation is required. Also slight variations in the size of the weld will not be as conspicuous as in the scarfed joints. Both sides of the joint should be welded if it is to resist flexure between the plates or if the stresses are high. Frequently this is not necessary when the rigidity of the part as a whole is considered.

Fillets Preferable to Butt Joints

Rounded outside corner construction shown in *f* is undesirable because the pieces being joined must be cut exactly to size and no supporting surfaces are provided to assist in fitting the parts together. Also, it will be difficult to build the weld uniformly into the shape shown. The design shown in *g* is structurally just as sound and overcomes these difficulties. The bent corner shown in *h* is superior to either of these since it will be just as strong and can be made much more quickly than the welded corner and will have a better appearance. For the same reasons of easier fitting and less preparation time required, fillet joints should generally be used in preference to butt joints wherever this is consistent with good strength and appearance.

A welding design should always be prepared with some thought to having access to all joints for weld-

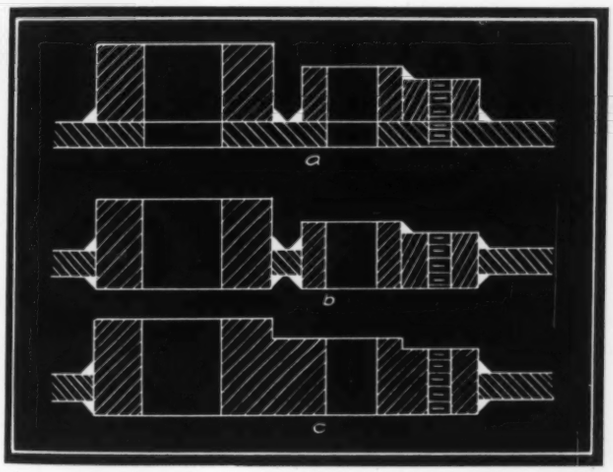


Fig. 4 — Drawings — above — illustrate a wrong and two right methods of incorporating bosses in welded assemblies

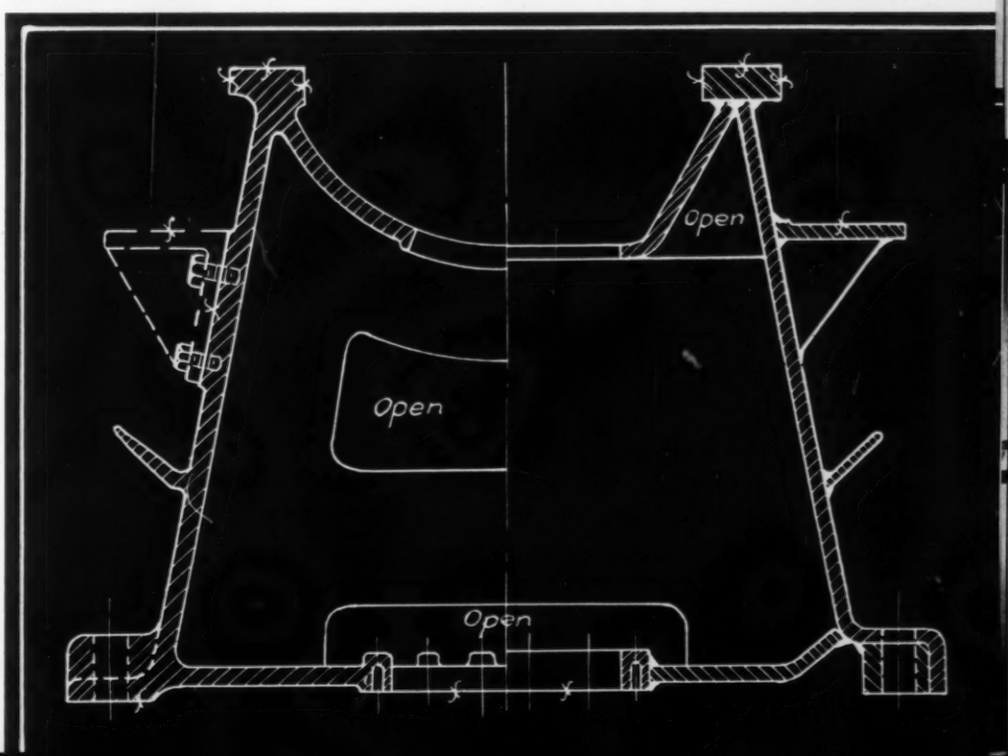


Fig. 5—Right—Composite view of cast and welded design of machine base shown in Fig. 1 demonstrates the engineering perspective vital to economical welded fabrication

ing. Sometimes, in complicated pieces, holes must be made specifically for this purpose but usually holes already required can be so arranged as to serve this purpose or, on some pieces, the welding can be done in stages during assembly.

Castings are commonly designed with flanges which are thicker than the main body of the piece. In welding, this is sometimes necessary, otherwise it may be possible to bend the flange, thus eliminating a weld. Design for welding should provide for a minimum scrap loss; pieces should be laid out to fit into one another in the flat plate development, and wherever possible similar pieces should be made identical so that single templets can be used in flame-cutting.

Close surface contact between two plates welded together cannot be depended upon unless the pieces are small and attention is specifically called to this requirement. Large pads will buckle and raise at the center due to the shrinking action of the weld around the edges unless plug welds are used. These must be made before the periphery is welded. Plug welds will be better and cheaper if large holes are made two to four inches in diameter with a single fillet joining the edge of the hole to the plate below. Small holes completely filled are not good because welds made in such confined spaces are likely to be unsound. Larger holes are not objectionable since the pad surfaces are usually not visible in the finished piece. Bosses around machined holes should not be applied to the outside of a wall as in *Fig.* 4*a*, but rather run entirely through the wall as in *b*.

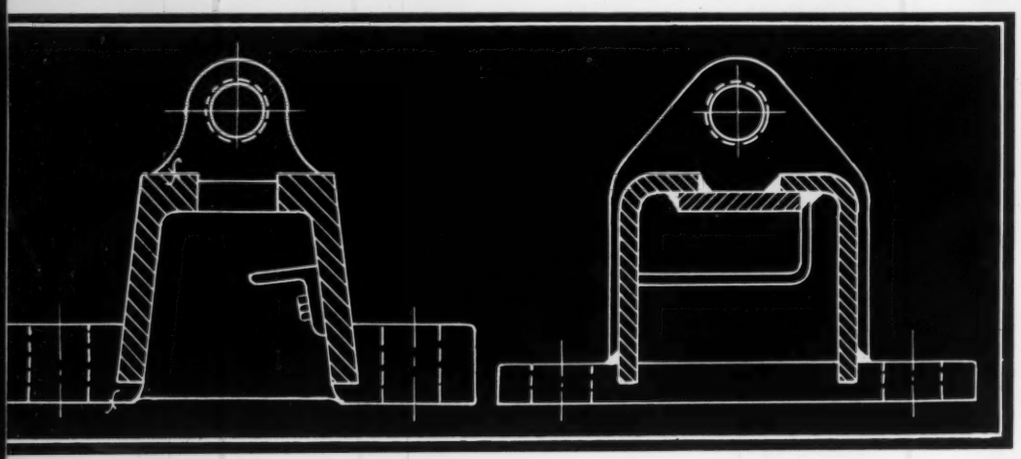


Fig. 6—End view of slide rail illustrated in Fig. 3 shows the distinction between cast and welded designs

Another question of importance is the amount of weld specified for each joint. Sometimes the welding specified may be insufficient for proper strength or rigidity. This difficulty is not likely to develop in the engineering department but may occur where detailed welding specifications are not given and the shop is obliged to determine the amount of welding to be done. Usually, however, the specifications call for more welding than necessary. A great many joints do not need to develop the full strength of the pieces joined. Many of these require only intermittent welding to insure proper strength and rigidity in the structure. Care should be taken to avoid over-welding because this is a critical factor in determining the cost of the piece. In addition, this extra welding may cause excessive distortion which later will cause trouble and be expensive to correct.

It will sometimes prove economical to use steel castings in the more complicated parts of a welding. This is true where a portion of the entire piece would involve an amount of scrap and labor out of proportion to the weight involved. As an example, the section shown in *Fig.* 6*c* might logically call for a casting.

Facilitates Repair of Damage

Figs. 5 and 6 demonstrate differences in the machine base and slide rail between a design for casting and the design for fabrication by welding. In *Fig.* 5 it will be noted that the ways are made from bar stock and the finished surface on the outside has been increased to match the inside dimension. The semicircular trough has been changed to incorporate two bends. The bead around the opening in this piece has been eliminated. A separate side bracket has been made an integral part of the welding. The thin section of the coolant trough is difficult to cast and easily broken on the finished piece. If the steel lip should be damaged it can be easily straightened. The central opening in the diaphragm shown is not a functional part of the base and has been omitted in the welding. The small upper triangle in this diaphragm contributes little to the stiffness of this base and adds disproportionately to the cost because of the scrap and extra cutting involved. It is therefore omitted in the design for welded fabrication.

The base ring on the welding could be made similar to the casting by welding a bar along the bottom but this would involve tedious fitting and considerable additional welding. Furthermore the design gives improved appearance.

Plate Serves Double Purpose

In *Fig.* 6 the raised bosses on the top surface of the slide rail have been eliminated since no machining is required. The top has been widened to make the flange of the bent side plates long enough to permit easy bending. The contour of the end piece has been altered to fit this new shape of the sides and incidentally improve the appearance. A bent plate is used inside the rails as a bolt head keeper in place of the angle used on the casting.

Guided by the foregoing precepts, the steps between the conception and execution of a design for flame-cut and welded fabrication should lead to the obtaining of the maximum advantages of this process. A proper application of the design criteria will result in a finished machine possessing attractive appearance as well as the engineered qualities of lightness consistent with strength and rigidity.

CO-ACTING DRIVE—

Electric Hydraulic MECHANICAL

By L. S. Andrich

Vice President
Snyder Tool & Engineering Co.

DEVELOPMENT of single-purpose, automatic machine tools has been stimulated recently by two primary factors. The first of these is the tremendous increase in military mechanization; the second, the shortage of skilled machinists necessary to produce military equipment on standard machine tools.

Performance of complicated machining operations to precise limits with automatic machines has called for considerable ingenuity in the solution of the resulting problems of drives and controls. Illustrated in *Fig.* 1 is a machine for milling the outside contour of radial airplane engine connecting rods. Representing a composite of electric, hydraulic and mechanical drives, the machine, after being set up, performs the complete milling operation without further attention.

Milled conn rods are shown immediately above the machine in *Fig.* 1. In milling such a contour the problem consisted of machining (1) the circular contour on the small end of the rod, (2) one side of the straight section, (3) the irregular contour of the large end, and (4) the remaining straight section. Furthermore, it was nec-

Fig. 1—Profile milling machine for shaping airplane engine connecting rods incorporates three separate drive systems

Fig. 2—Work process charts for profile milling operation shows the position in which the controlling limit switches are tripped

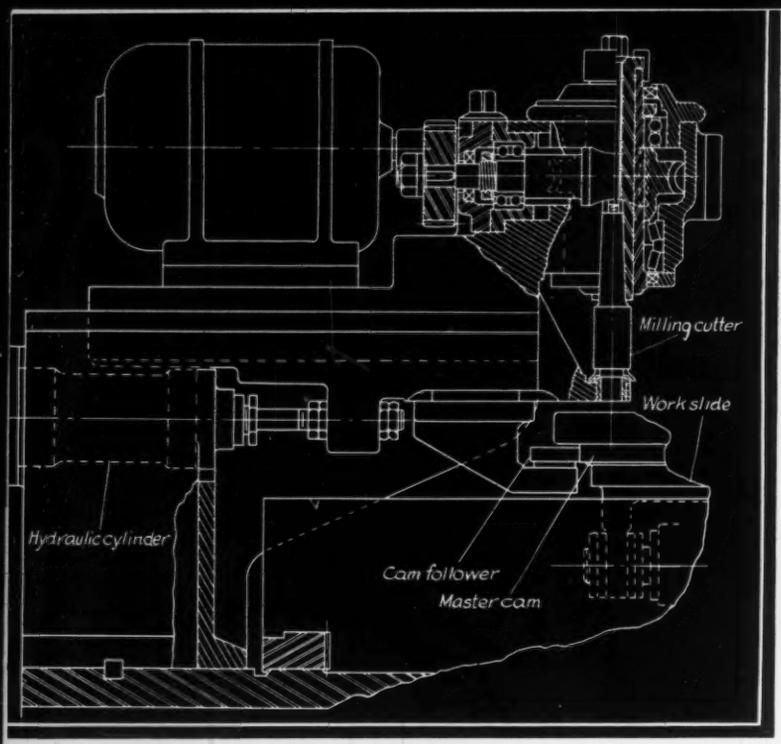


Fig. 3—Side elevation of the cutting tool spindle assembly is positioned axially by the master cam

essary that all these operations be accomplished at a substantially constant cutting speed.

Before considering in detail the drives and control systems by which these operations are accomplished, attention to the work process chart, *Fig.* 2, is desirable.

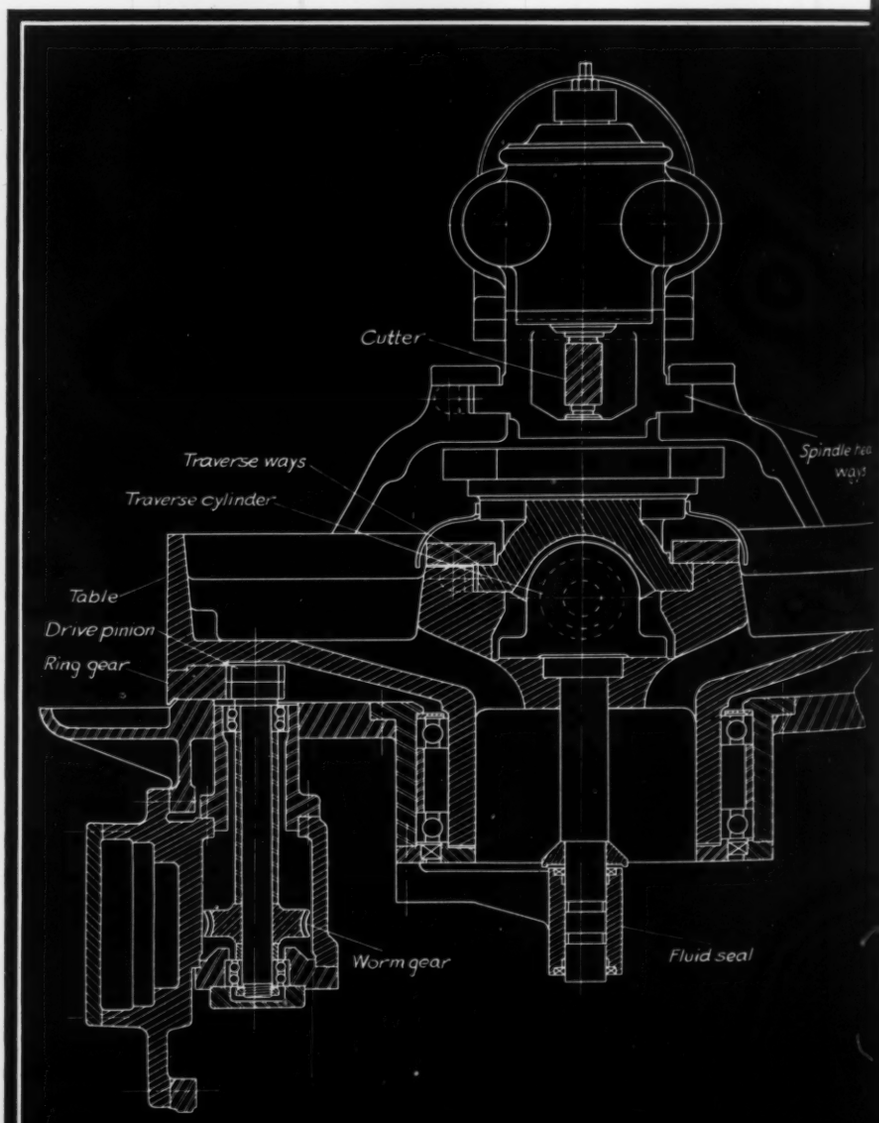
In the first or loading position the table, carrying a slide to which the blank is clamped, starts rotating clockwise and continues through approximately 142 degrees to the second position. During this movement of the table the small end of the rod, which is clamped at the center of rotation, is being milled. Rotation then stops and the work slide is moved in a straight line diametrically across the table to the third position, milling one side of the arm. Clockwise rotation of the table restarts and continues to the fourth position, finishing the large end of the rod. Diametrical straight-line motion then results in the finishing of the other straight side of the arm, returning the table and work slide to the first or loading position.

It will be observed from the foregoing that the entire series of operations is performed by a succession of rotary and straight-line motions of the work piece. In order to mill the irregular contour of the large end of the rod as well as to afford accurate conformation of the other portions, a master cam or templet is used integral with the work slide and similar in contour to the rod. This positions the milling cutter radially with respect to the rotatable table.

Shown in *Fig.* 3 is the entire spindle assembly in side elevation. Motor, gear head, spindle and cam follower roller are mounted on slidable ways on the machine base. The problem of maintaining positive following of the master cam was solved by use of a hydraulic cylinder. The cylinder is fastened to the machine frame and the end of the piston rod to the spindle carriage.

Rotatable table mounting and its drive are shown in the front sectional elevation, *Fig.* 4, as well as an end view of *Fig.* 3. The table is mounted for rotation on a pair of preloaded radial ball bearings. At the center of rotation of the table is a hollow conduit shaft which supplies hydraulic fluid to the traverse cylinder. This shaft is integral with the table. A novel feature of the design is that no packing for the pressure fluid is needed. A carefully lapped stationary sleeve is fitted over the end

Fig. 4—Rotation of the work table is effected by a pinion driving a ring gear which is integral with the table



of the shaft. Two annular recesses are formed in the shaft and are positioned opposite fluid supply holes in the sleeve. Ends of the sleeve are closed by simple oil seals. To prevent the exertion of fluid pressure against these seals, small recesses are formed in the sleeve and vented to the fluid sump. Thus the slight leakage past the closely fitted surfaces of the sleeve and shaft is returned to the hydraulic system.

Mounted on the under side of the outer periphery of the table is an internal ring gear. In addition to serving as the driving means, this gear also carries, on its lapped under surface, the entire downward thrust load of the table. This surface bears directly on the machine base which is hand scraped.

Mating with the ring gear is the table drive pinion, driven by the worm gear shown in *Figs.* 4 and 5. The worm gear is driven by an electric motor through V-belts, a pair of pick-off gears and two worms as shown in *Fig.* 5.

It will be evident from the foregoing that in order to obtain constant cutting speed on both the large and small ends of the connecting rod (during which operations the table is rotating) two different rates of table rotation are required. These rates, of course, vary inversely as the diameters of the rod ends. In the case of the large end of the rod, which is scalloped, the speed is based on the mean diameter. To obtain these different rates of table rotation a two-speed, three-phase electric motor is used as the drive.

Limit Switches Control Slide and Table

Limit switches are located at predetermined points around the periphery of the table. Their position is indicated schematically by their operating pawls shown in *Fig.* 2. Dogs fastened to the table operate these switches which stop the table rotation. Since at the conclusion of each angle of rotation of the table there follows a straight-line motion of the work slide, these limit switches also function to operate the hydraulic circuit which energizes the traverse cylinder.

At the conclusion of each straight line traverse stroke (except the last) a push rod fastened to an arm on the traverse cylinder ram operates a limit switch at the end of its stroke which stops the traverse. These same switches select the proper motor speed for whichever end of the connecting rod is in cutting position in the center of the table.

After the last stroke—when the rod is in the fifth position shown in *Fig.* 2—the tripped limit switch, in addition to stopping the traverse, also energizes the hydraulic circuit of the spindle slide cylinder causing the cutter to be retracted from the work.

Discussion of the design to this point shows that the table rotation and work slide traverse serve only to position approximately the surface being milled with respect to the cutter. The actual profiling is accomplished by motion of the spindle carriage on its ways caused by the action of the follower roller on the master cam. This introduced a serious problem in the original design because during backward motion of the spindle carriage, the ram had to be forced backward against the pressure behind the piston resulting in extreme loads on the cam follower. Shown in *Fig.* 6 is the hydraulic circuit for the spindle slide cylinder which indicates how this difficulty was overcome.

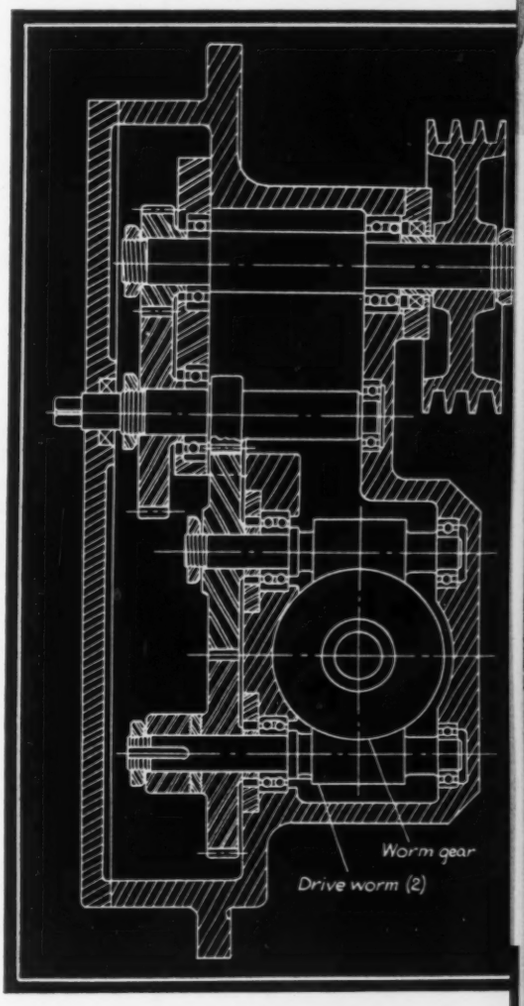


Fig. 5—Play in the worm gear and worm wheel drive assembly is eliminated by the use of an auxiliary driving worm gear

A by-pass line was installed between the ends of the spindle slide cylinder. In this line was installed a variable metering valve and a check valve. The metering valve is controlled by the master cam in such a manner that, as the spindle carriage moves backward, the valve is opened permitting fluid to flow through the check valve to the other end of the cylinder.

Feed pump shown in *Fig.* 6 supplies pressure fluid through the 4-way control valve to hold

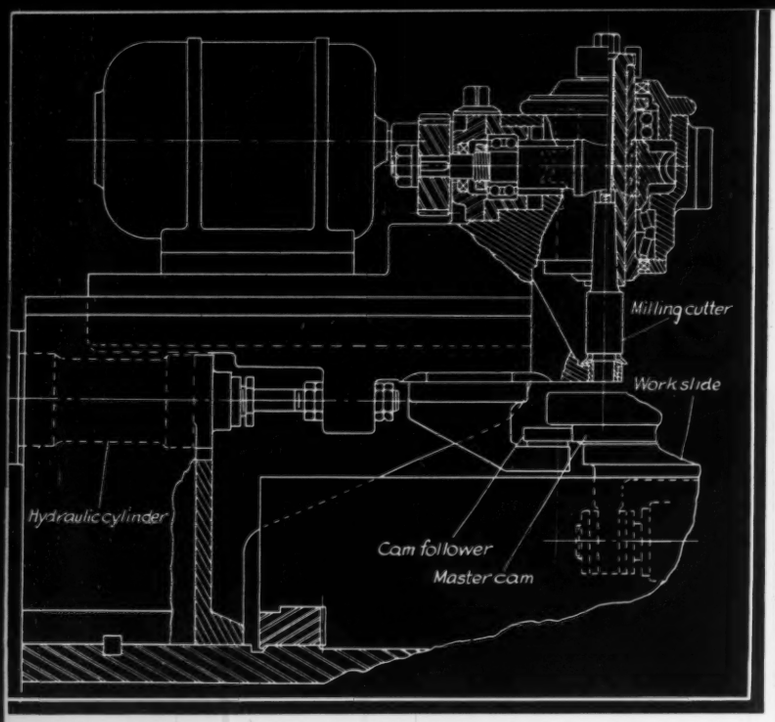


Fig. 3—Side elevation of the cutting tool spindle assembly is positioned axially by the master cam

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Before considering in detail the drives and control systems by which these operations are accomplished, attention to the work process chart, *Fig.* 2, is desirable.

In the first or loading position the table, carrying a slide to which the blank is clamped, starts rotating clockwise and continues through approximately 142 degrees to the second position. During this movement of the table the small end of the rod, which is clamped at the center of rotation, is being milled. Rotation then stops and the work slide is moved in a straight line diametrically across the table to the third position, milling one side of the arm. Clockwise rotation of the table restarts and continues to the fourth position, finishing the large end of the rod. Diametrical straight-line motion then results in the finishing of the other straight side of the arm, returning the table and work slide to the first or loading position.

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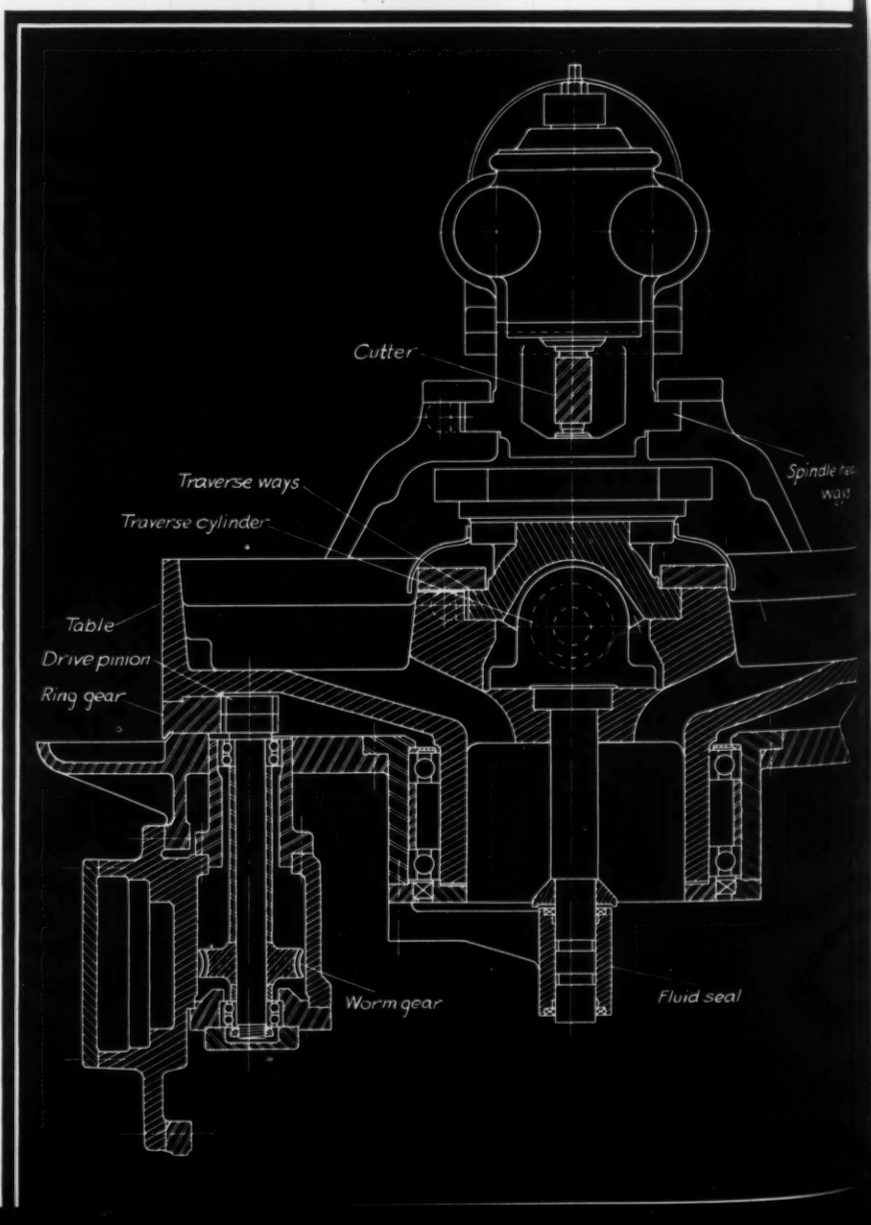

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Mounted on the under side of the outer periphery of the table is an internal ring gear. In addition to serving as the driving means, this gear also carries, on its lapped under surface, the entire downward thrust load of the table. This surface bears directly on the machine base which is hand scraped.

Mating with the ring gear is the table drive pinion, driven by the worm gear shown in *Figs.* 4 and 5. The worm gear is driven by an electric motor through V-belts, a pair of pick-off gears and two worms as shown in *Fig.* 5.

It will be evident from the foregoing that in order to obtain constant cutting speed on both the large and small ends of the connecting rod (during which operations the table is rotating) two different rates of table rotation are required. These rates, of course, vary inversely as the diameters of the rod ends. In the case of the large end of the rod, which is scalloped, the speed is based on the mean diameter. To obtain these different rates of table rotation a two-speed, three-phase electric motor is used as the drive.

Limit Switches Control Slide and Table

Limit switches are located at predetermined points around the periphery of the table. Their position is indicated schematically by their operating pawls shown in *Fig.* 2. Dogs fastened to the table operate these switches which stop the table rotation. Since at the conclusion of each angle of rotation of the table there follows a straight-line motion of the work slide, these limit switches also function to operate the hydraulic circuit which energizes the traverse cylinder.

At the conclusion of each straight line traverse stroke (except the last) a push rod fastened to an arm on the traverse cylinder ram operates a limit switch at the end of its stroke which stops the traverse. These same switches select the proper motor speed for whichever end of the connecting rod is in cutting position in the center of the table.

After the last stroke—when the rod is in the fifth position shown in *Fig.* 2—the tripped limit switch, in addition to stopping the traverse, also energizes the hydraulic circuit of the spindle slide cylinder causing the cutter to be retracted from the work.

Discussion of the design to this point shows that the table rotation and work slide traverse serve only to position approximately the surface being milled with respect to the cutter. The actual profiling is accomplished by motion of the spindle carriage on its ways caused by the action of the follower roller on the master cam. This introduced a serious problem in the original design because during backward motion of the spindle carriage, the ram had to be forced backward against the pressure behind the piston resulting in extreme loads on the cam follower. Shown in *Fig.* 6 is the hydraulic circuit for the spindle slide cylinder which indicates how this difficulty was overcome.

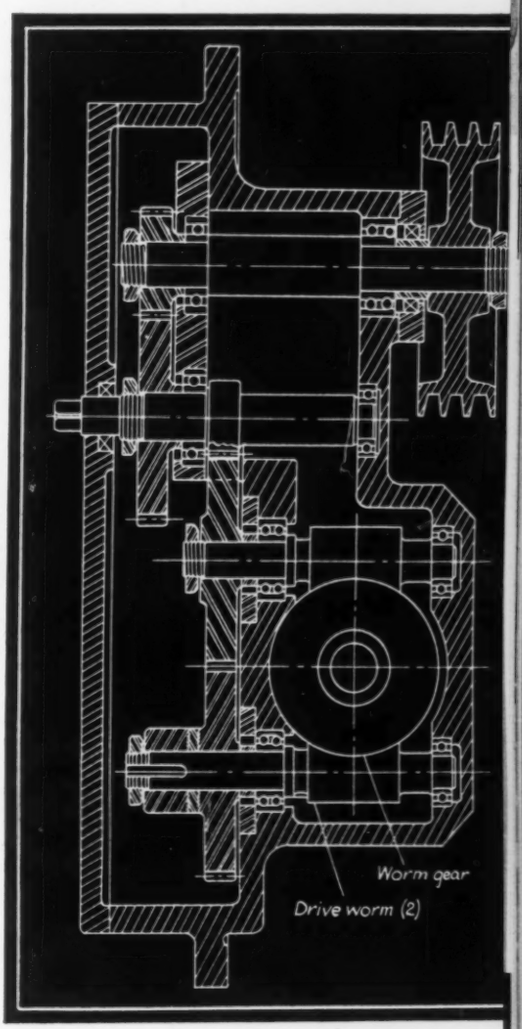


Fig. 5—Play in the worm gear and worm wheel drive assembly is eliminated by the use of an auxiliary driving worm gear

A by-pass line was installed between the ends of the spindle slide cylinder. In this line was installed a variable metering valve and a check valve. The metering valve is controlled by the master cam in such a manner that, as the spindle carriage moves backward, the valve is opened permitting fluid to flow through the check valve to the other end of the cylinder.

Feed pump shown in *Fig.* 6 supplies pressure fluid through the 4-way control valve to hold the

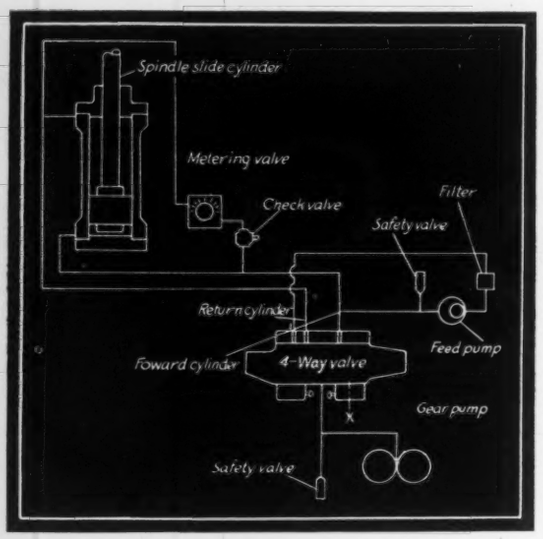
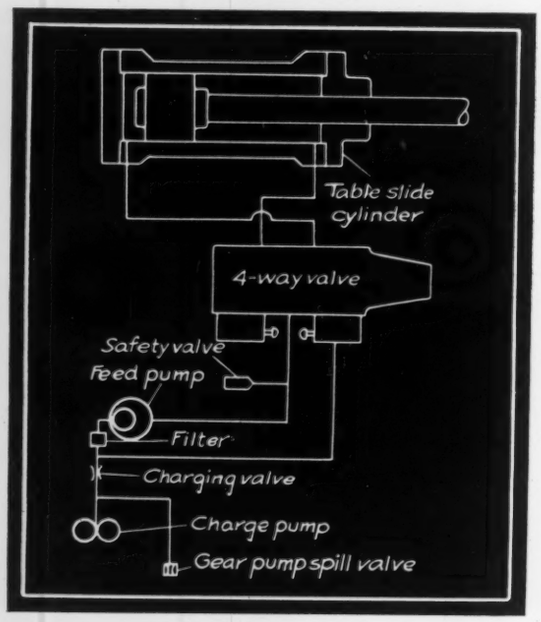


Fig. 6—Metering valve in the hydraulic circuit for the spindle carriage controls the load which the follower exerts on the master cam

follower against the cam. An auxiliary gear pump supplements the feed pump for rapidly retracting or advancing the cutter.

Toward the end of each straight-line cutting traverse the table feed cylinder continues to drive the work until cutting has been started on the rounded ends of the rod. As machining starts on this curved section the angle between the spindle carriage ways and the normal to the tangent to the contour at the cutting point increases appreciably. Since the cam follower bearing load is an inverse function of the cosine of this angle the bearing load increases rapidly at this point. To carry the load a hardened-steel plain bearing, running on a hardened steel shaft, is used with flood lubrication. Both bearing surfaces are hardened to 62-64 Rockwell C.

Fig. 7—Charge pump compensates for the volume of the piston rod in the closed hydraulic circuit of the table slide cylinder



Controlled by a 4-way solenoid-operated valve and supplied by a variable displacement feed pump, the hydraulic circuit for the table slide cylinder is shown in *Fig.* 7. Since this is a closed circuit, fluid from one end of the cylinder passes directly through the control valve, through the feed pump, back through the control valve to the other end of the cylinder. However, as the piston shown in *Fig.* 7, moves from the left to the right, the rate of decrease of fluid volume to the right of the piston is less than the corresponding rate of increase on the left due to the volume of the piston rod. To augment this deficient flow of fluid to the head end of the cylinder a gear type charging pump is used which replenishes the head end fluid from a sump.

It is essential in order that the table be rotated without vibration and also be held rigidly while the work slide is being traversed that all backlash be eliminated from the table drive gearing. To this end the drive pinion shown in *Fig.* 4 is split in a plane normal to its axis, the parts being held together by set screws. Upon installation, the sections are displaced angularly with respect to each other until all backlash with the teeth of the ring gear is taken up. The sections are then locked in position.

Minor Changes Afford Versatility

Play is eliminated from the worm and wheel drive in a similar manner. The lower of the two driving worms in *Fig.* 5 is provided with a serrated locking clutch washer and nut. The nut is loosened and the worm rotated until positive contact between the two worms and the worm gear is attained. The lower worm is then locked in position. Any play in the spur gears which drive the worm cannot, of course, carry through the worm and wheel drive.

Whereas this machine is set up for the specific purpose of profile milling connecting rod contours it is evident that it may also be adapted to a wide variety of other shapes. This can be accomplished by (1) providing a master cam for the new contour, (2) repositioning the limit switches around the work table, (3) changing the pick-off gears in *Fig.* 5 to adjust table rotation rates, and (4) adjusting the variable displacement hydraulic pump in *Fig.* 7 to provide the proper rate of work slide traverse.

If the new contour should require more than two rates of table rotation, the two-speed motor can be replaced by a variable speed motor. Speed control is then obtainable from the master cam.

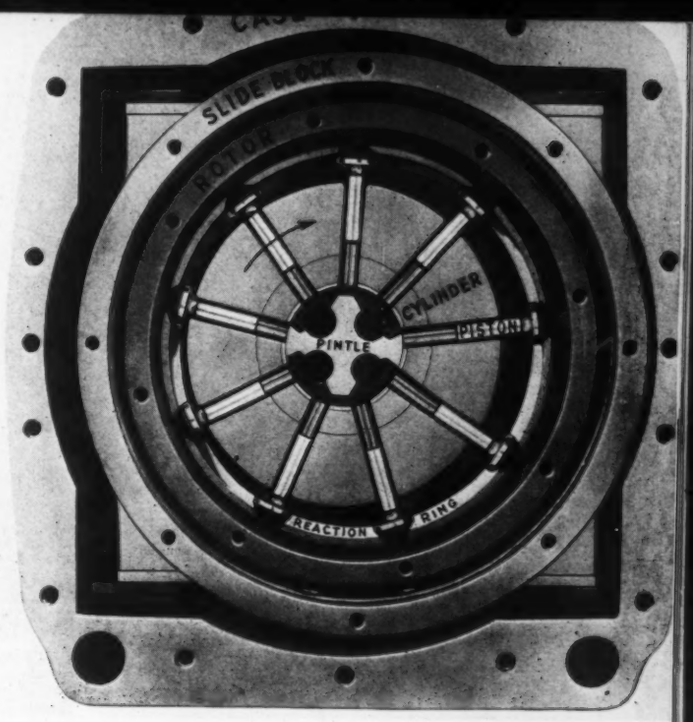


Fig. 1—Radial type, variable displacement piston pump is capable of controlling fluid flow from maximum in one direction, through zero, to maximum in reverse. May be used as a motor if desired

How To Select Hydraulic Power Equipment

By Christian E. Grosser

SELECTION of the proper hydraulic equipment is the second step in the process of applying hydraulic drives in the design of machines. It is assumed the designer has already established that his problem of power transmission or control may be solved efficiently by application of one of the basic hydraulic circuits described in the previous article of this series (M. D., December, page 37), or possibly by a combination of these circuits.

It is necessary at this time to point out that the aforementioned circuits were offered only as simple illustrations, in skeleton form, of the essential means by which the more noteworthy functions of hydraulic transmission and control may be performed. In addition to the elements shown, other items of equipment must necessarily be included for successful operation. Such secondary elements include oil storage tanks, filters, coolers, leakage re-

CONCERNED with basic hydraulic circuits, the first article of this series which appeared in the issue of December, 1940, discussed the scope and application of hydraulic drives and controls. The current article deals with commercially available equipment and the general considerations governing their selection

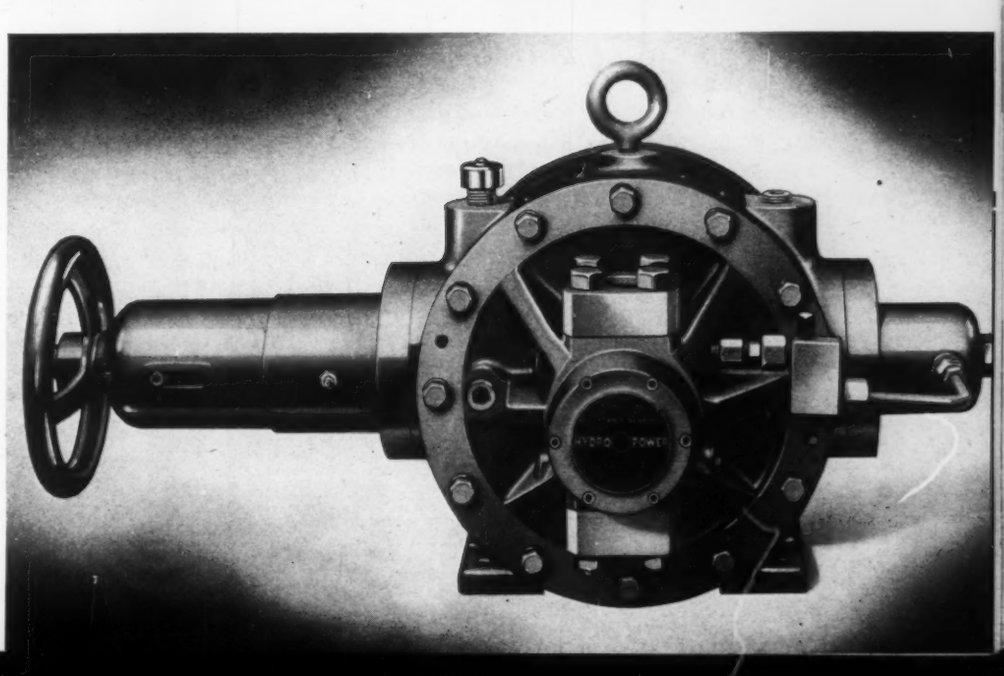


Fig. 2—Extreme high pressure variable displacement pump incorporating manual and servo-control. This unit is a specialized form of the radial piston type

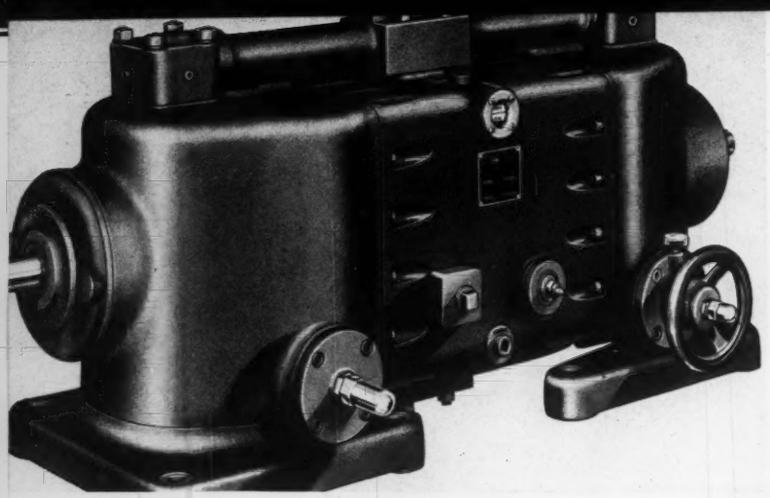


Fig. 3—Axial type piston transmission is a completely self-contained unit embodying all auxiliary apparatus

plenishment devices, drains, safety relief valves, etc.

While this discussion will concern itself more with the considerations governing the choice of the main circuit components such as pumps, motors and control devices, the secondary auxiliary items must and will be given some attention in recognition of their importance in the success of the hydraulic drive.

Established manufacturers of hydraulic equipment, numbering several score, offer a complete assortment of standardized units covering all the essential components of the most common hydraulic systems. However, the design and construction of individual manufacturers differ considerably. Some designs are versatile in application. Others are highly specialized and well suited only in a restricted field of use. As an illustration of this point we may cite a type of piston pump offered by several manufacturers primarily as a power transmission element. Such units are moderately rated as to pressure capacity but exhibit comparatively high power-to-weight ratios, good efficiencies, low slip and interchangeable operation as pumps or motors. They are extremely versatile in handling general power transmission or control problems. However, they are not well adapted to specialized applications involving either extremely high oil pressure applications or large volume pumping operations. In the smaller sizes they are prohibitively high in cost and are supplanted there by less efficient but lower cost equipment.

High pressure pumps used for hydraulic press actuation produce extreme pressures at a relatively low volume rate. In press operation this characteristic permits the use of minimum size rams and consequently reduces appreciably the size and cost of large press machinery. However, such high pressure pumps are not as well suited to other drive applications (such as aircraft or marine) as are certain more moderately rated units, since the design for extreme pressure usually involves a relatively low power-to-weight ratio. In addition, the high pressure pump units usually are not well suited to operation as motors because of high inertia of their revolving parts. Again, certain kinds of low pressure, high displacement equipment having low cost as a chief characteristic do not exhibit high enough efficiencies or sufficient resistance to slip, to perform properly in transmitting large quantities of power nor to carry out exact control functions.

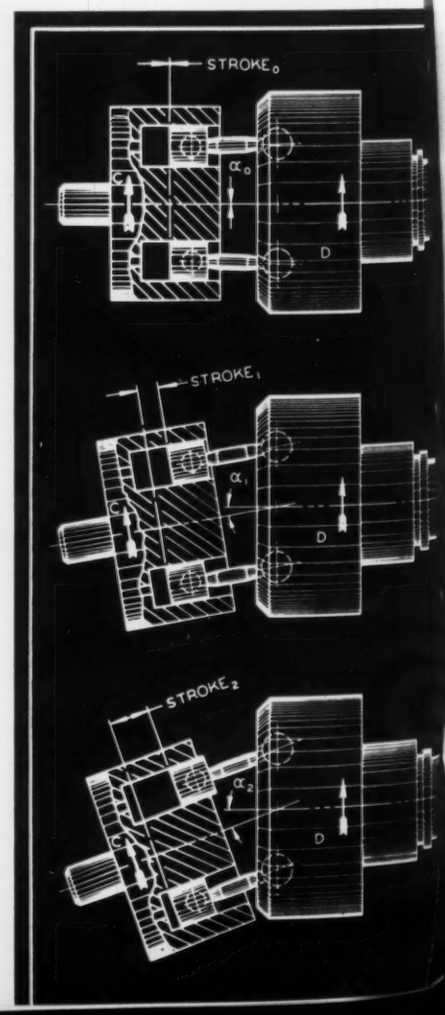
The designer should avail himself freely of the engineering advice offered by the equipment manufacturers who are co-operative in supplying performance data, descriptive literature, and guidance through their engineering representatives.

The great bulk of hydraulic applications now lies in the power range between approximately five horsepower to somewhat under one hundred horsepower. Below this range the extreme accuracy required in the manufacture of hydraulic equipment, in order to scale down clearances to proper values, makes its cost prohibitive for ordinary purposes. In such capacities mechanical or electrical drives offer many practical solutions. Above the range mentioned, the infrequent use and limited availability of large hydraulic equipment is due principally to lack of development. Under the pressure of demand from designers, manufacturers are steadily developing larger units. There are no serious handicaps of high cost of manufacture or decreasing performance characteristics operating against advances in this direction.

Hydraulic equipment may be considered for convenience under the following four classifications: (1) Pumps and motors, including cylinder rams; (2) control elements, such as valves, pump stroke adjusting mechanisms, etc.; (3) flow media, such as pipes, flow passages, fittings, etc.; (4) auxiliary apparatus, such as oil storage tanks, supercharging pumps, oil filters, coolers, gages, etc.

The first three classes are the primary elements in any given circuit. After an operating circuit has been laid out the necessary characteristics of these elements must next be determined and se-

Fig. 4—Diagram indicates piston-actuating mechanism of axial type pump as well as method of varying stroke



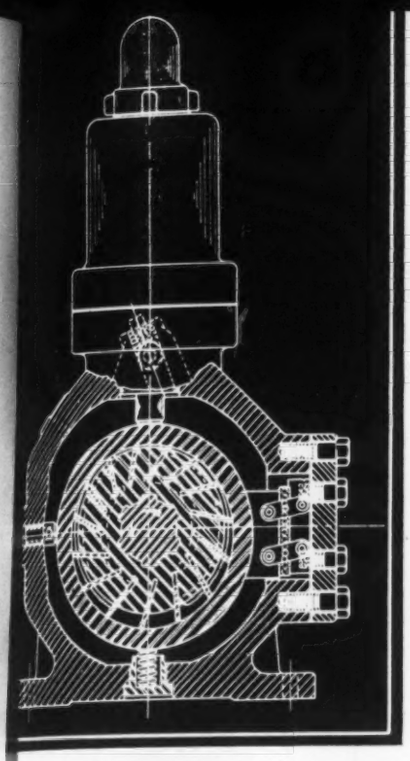


Fig. 5—Variable displacement vane type pump which restricts flow to one direction

lections made. Auxiliaries may or may not have to be added later as analysis of the conditions of operation reveals necessity for them.

(1) PUMPS, MOTORS, CYLINDERS, ETC.: In general, pumps and motors may be considered identical in construction and interchangeable in operation. There are a few instances when this is not true. Vane type pumps cannot be used as motors since current construction depends upon the "centrifugal" force of rotation in the actuation of vanes and, consequently, motor operation at low speeds or at standstill is impossible. Gear type machines are not usually interchangeable in operation. Some specially designed radial pumps, made principally to produce high pressures at low delivery rates, should not be used as motors because of the relatively low efficiency in such operation and high inertia of rotating parts.

Pumps and motors considered together fall generally into two groups, named, for convenience: (a) Variable displacement and (b) constant displacement. Variable displacement units may be adjusted to vary the amount of liquid which may pass through them during a shaft revolution. Constant displacement equipment cannot be so adjusted. Most units of the "variable" type may be continuously adjusted in displacement rate from a maximum flow in one direction through zero to an equal maximum flow in the reverse direction.

Constant displacement units are usually of simpler construction than the variable types since they have no stroke-adjusting mechanism and also because they may employ much simpler principles of displacement which, however, do not lend themselves readily to variation of stroke. Gear type pumps, for example, cannot conveniently be varied in displacement. In consequence of their greater simplicity, the constant displacement types are available in greater variety than the variable types. All variable type units are available in constant displacement form since the difference involves only the elimination of a stroking mechanism and the modification of the housing.

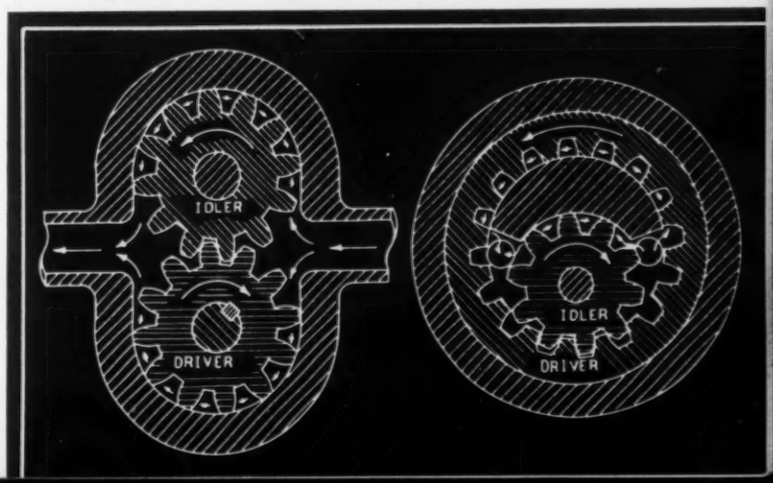
Variable displacement units are of three types: Multiple "radial" piston, multiple "axial" piston, and multiple vane. The constant displacement types are available in the same constructions as these and additionally in a large number of gear and screw type constructions.

The radial piston type pump, such as illustrated in *Fig.* 1, is well adapted to both medium pressure, high displacement operation and to high pressure, low displacement design. It is available in both forms. The illustration is that of a pump designed primarily for transmission purposes to operate at pressures below 2000 pounds per square inch and at moderately high displacement rates. This type may be obtained with a good power-to-weight ratio and good efficiency characteristics. It may be used interchangeably as pump or motor and is obtainable in both constant displacement and variable displacement designs. (Modification of radial style of unit by special valving and reduced piston diameters produces the extreme high-pressure pumps illustrated in *Fig.* 2 which may operate at pressures above 3000 pounds per square inch—used particularly for press applications). Radial piston units are available in capacities ranging from approximately 5 to 100 horsepower.

Axial piston types, of which *Figs.* 3 and 4 are examples, are well suited to general power transmission purposes, being characterized by high power-to-weight ratio, high efficiency, low slip, and complete interchangeability as pumps and motors. Of the piston type units they have the lowest rotational inertia and consequently they respond readily to high accelerations. A noteworthy feature of most axial units is their ability to take up wear automatically on their plane commutating valve surfaces. Consequently internal leakage or slip increases relatively slowly during the life of the machines. They may be obtained either in the variable or constant displacement forms and range in power from approximately 5 to 300 horsepower.

Vane type pumps are essentially for large displacement rates and moderate pressure operation. As pointed out above they cannot be applied as motors. They are of both constant and variable displacement forms. *Fig.* 5 is an example of the latter. A principal asset of vane design pumps is their low cost and low weight per unit of power. Their operating pressure limit is somewhat below 1500 pounds per square inch. Overall efficiency of

Fig. 6—Two forms of the widely used gear type pumps which are also available as hydraulic motors



operation is not as high as that of piston type equipment, nor is the volumetric efficiency good, since slip is relatively higher. Used in smaller power circuits ranging from approximately one horsepower to 25 horsepower, these pumps see much service in machine tool drive and feed applications where efficiency is not a primary consideration.

Gear type pumps and motors, of which two forms of construction are indicated diagrammatically in *Fig.* 6, are the least versatile power transmission units. They are restricted to constant displacement characteristics and while they may be designed to operate either as pumps or motors it is not always possible to interchange operation of a given unit. Mechanical efficiencies are lower than those of piston types and somewhat less than those of vane pumps. Their chief advantages are low

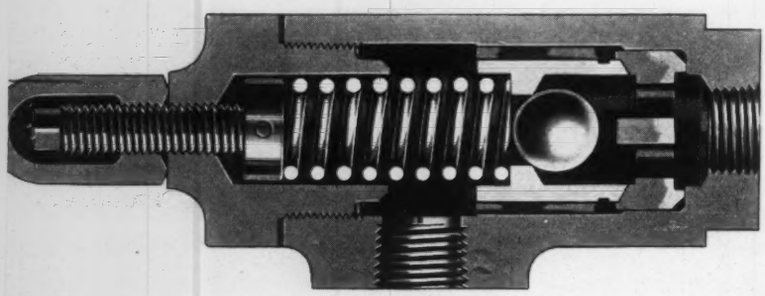


Fig. 7—Combination pressure relief and replenishment valve provides a sealed adjustment for pressure

cost, low rotational inertia, and simple construction. Their capacity ranges from fractional horsepower to possibly 25 horsepower.

Gear type units are available in a large number of forms and makes. Most of them are used more for the simple function of pumping liquids, rather than as transmission members.

The remaining item in this classification is the hydraulic cylinder, or ram, used for obtaining motions of translation from a hydraulic circuit such as in table feeds, broaches, presses, etc. Cylinders are naturally used only as motors and can have only constant displacement characteristics. There is available on the market a good variety of standard designs and sizes for high pressure.

(2) CONTROL ELEMENTS: Most important of the control elements in a hydraulic transmission circuit are the stroke controls which regulate the displacement rates through variable type pumps or motors. In the simplest form they consist simply of levers or handwheels by which only manual direction of displacements or speeds is obtained. Such controls are generally furnished as integral parts of the variable type machine and are available in a number of alternative arrangements on a given machine. Manual controls may be elaborated to include standardized remote control (by electric motor circuit or by a small circuit.

Automatic, pressure-responsive, displacement controls such as are needed in constant torque or controlled-power circuits are available with most types of variable displacement units—particularly with those designed for power transmission.

Of the other control elements in common use, the metering or "constant flow" valve is a commercial item worthy of attention. Available in standardized units, it is used in conjunction with small constant displacement pumps to produce the same result as a variable displacement unit, but at a greatly reduced cost. Standard metering valves with direct dial indication of flow will maintain an almost invariable rate under large fluctuations of imposed pressure and under reasonable variations in oil temperature.

Provide Wide Range Pressure Control

Included in the remaining group of control items are all the various valves which are used to close off circuit flow, reverse its direction, divert it from one circuit to another, etc. Valves of these kinds are offered as standard items in almost countless variety of types and sizes to meet almost any circuit requirements.

(3) FLOW MEDIA: To connect together the component parts in the hydraulic circuit, high pressure seamless tubing is the most practical medium. This tubing is available in various strengths depending upon the peak pressures to be handled; materials are copper or steel. Connections are available in the form of screw thread mounted compression fittings in the smaller sizes; gasketed and bolted flanges in the larger sizes. Flanges may be attached to the tubes by silver soldering, brazing or welding.

Where the transmission elements are close together, intermediate piping may often be avoided. Many manufacturers offer hydraulic transmissions as integral units with flow between elements carried by passages in a common casting connecting the pump, motor, control valves, etc.

(4) AUXILIARY ELEMENTS: Auxiliary apparatus is of a varied nature dependent somewhat upon the characteristics of the pump and motor elements and very largely on the conditions of operation. Usually safety relief and supercharging equipment is furnished by the manufacturer as integral parts. If not, recommendations for separate elements to be included in the circuit, as well as sources of supply, may always be obtained.

The author wishes to acknowledge the assistance of equipment manufacturers in supplying illustrations, among which are: Hydro-Power Systems Inc., Div. of Hydraulic Press Mfg. Co. *Fig.* 2; Racine Tool and Machine Co. *Fig.* 5; The Oilgear Co. *Figs.* 1 and 7; Vickers Inc. *Figs.* 3 and 4.

Provides Two Presses in One

By J. P. Jenny

Field Engineer
The Oilgear Co.

IN this group of short articles are discussed solutions to particular drive and control problems. Designed to meet the requirements of a specific machine, each application utilizes principles adaptable to other types of machines. Ideas thus obtained often lead to better designs

Ingenuity Simplifies Designs

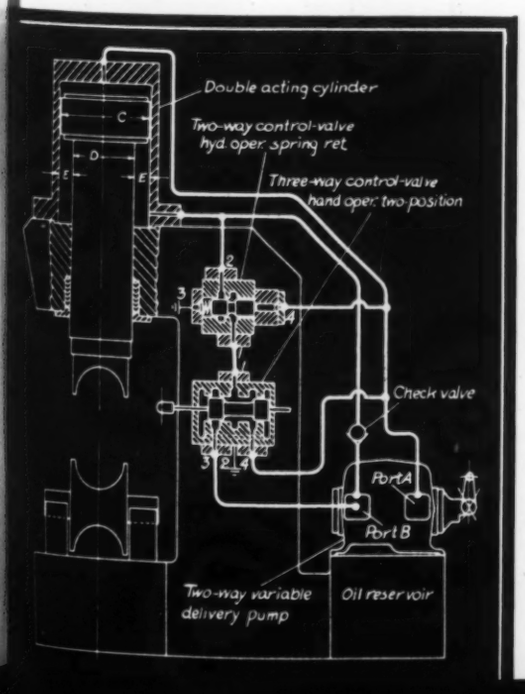
TO PROVIDE differential working pressures in a hydraulic gooseneck straightening press, back pressure is utilized in the double-acting ram cylinder of the press. In this way the hydraulic circuit economically provides either a 200 or a 300-ton press.

Equipped with a two-way variable displacement pump, the press provides two-stage tonnage through a hand-operated, two-position, three-way valve and a hydraulically operated, spring-return, two-way valve. The illustration shows a schematic oil circuit for this arrangement.

When it is desired to operate the press up to 200 tons, the hand-operated valve shifts the pump control so that the delivery is at port *A*. This creates a pressure at the top, or head end, *C*, of the cylinder and on port 4 of the two-way valve. Pressure on this port shifts the valve plunger from the normally closed position to the open position which allows free flow from port 1 to port 2 of the two-way valve. With the three-way valve in the 200-ton position, port 1 is connected to port 4. The press cylinder then has equal pressure on both sides of the piston, and the piston moves down on the differential area *D*. The oil discharged from the bottom of the cylinder is returned to the top. Ram cannot move downward until pressure in the line from port *A* shifts the two-way valve plunger.

When it is desired to operate the press up to 300 tons, the hand-operated, three-way valve is set in the 300-ton position. This connects port 1 to port 3. In this case, pressure at port *A* of the pump is connected to the head end of the cylinder and to port 4 of the two-way valve, shifting the valve plunger as before; but the ram end of the cylinder is connected to port *B*, or the return connection of the pump. The speed of the press is then determined by the volume delivered by the pump working on area *C*. The working pressure will be that pressure required on area *C* necessary to overcome the external load up to the maximum working pressure of the pump. The maximum pressure on area *C* creates a 300-ton force at the ram nose.

In either case, when the pump control is shifted so that the pump delivery is at port *B*, the ram returns at a speed determined by the volume delivered by the pump working on area *E*.



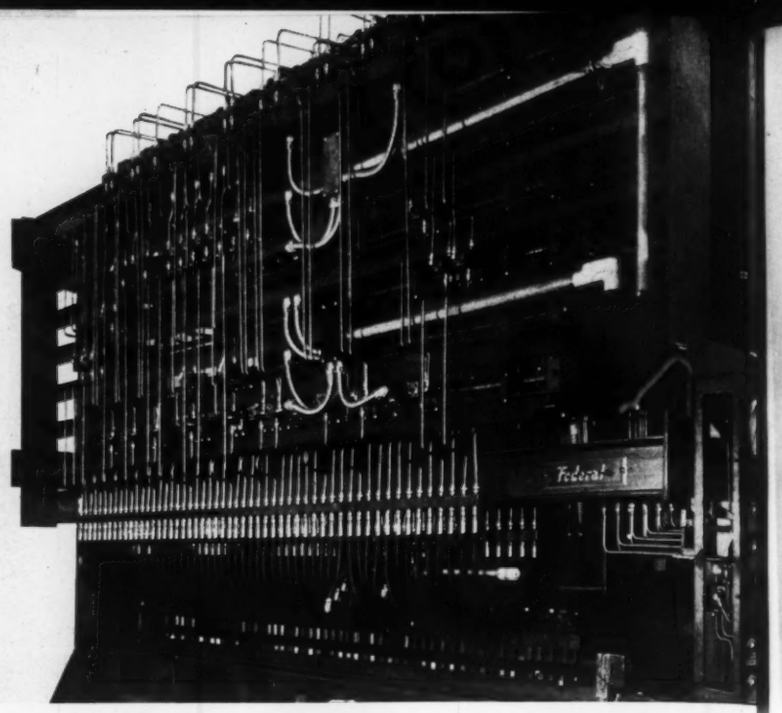
Adjustable Cams Give Flexibility

By W. E. Klingeman

The Federal Machine & Welder Co.

UNIQUE means for accurately controlling the location of spot welds on a welding machine utilizes hydraulically operated rotary valves equipped with automatic trip electrical timing devices. The component parts to be welded are

Ingenuity Simplifies Designs



various reinforcing members spot-welded to sections of railroad passenger cars and are moved through the machine by a conveyor mechanism.

As the conveyor locates the work for each operation under a row of welding guns, the operator stationed at a central control panel may select the necessary manually operated, hydraulic four-way pilot valves to suit the operation arising. Each of the manually operated pilot valves control double-acting cylinders that actuate the shafts to which adjustable cams are attached. As the cams trip the small hydraulic pilot valves, the welding gun piped from that particular valve is not operated and even though the welding current is turned on, the welding circuit is not completed since the electrode does not come down upon the work. These small pilot valves, when tripped, automatically by-pass the oil back to the rotary valve mechanism. A cam and limit switch is also mounted on each set of control shafts as a safety measure to insure correct operation before welding current is initiated.

The design is proving a comparatively simple means of controlling a complicated machine and has considerably lowered the cost factor. It is also flexible in operation by allowing many of the spot locations to be changed without doing anything more than changing pilot valves and cams.

Drive Is Designed for Tough Service

By H. C. Hettelsater

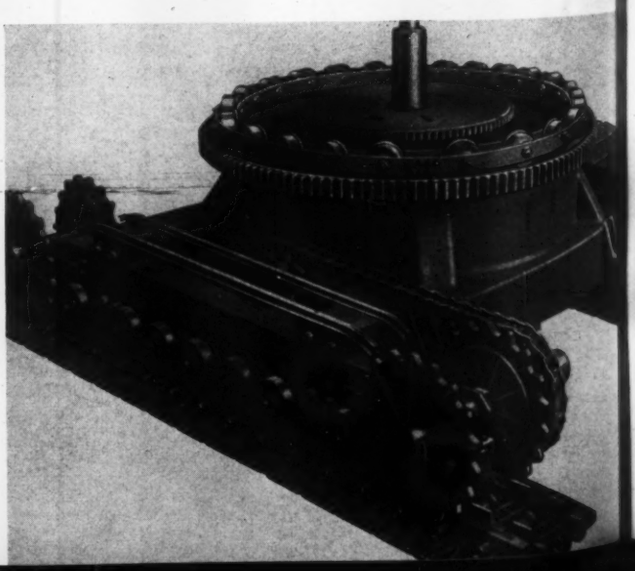
Standards Engineer
Harnischfeger Corp.

CRAWLERS to support excavators operate on the same principle as roller chains, consisting of links and pins which are driven around the true arc of a circle. In the crawler illustrated, the shoes or pads function as the links of the roller chain, and the shoe pins act the same as the pins in the chain.

Double sprockets, which drive the crawlers, engage the shoe pins and transmit the driving torque to the shoes with a smooth rolling motion. These sprockets engage each shoe pin at two points, this serving to keep the shoes in line and also to distribute the wear on the pins. The sprockets are designed so that every other tooth engages a pin in the shoe, allowing for turning the sprocket a distance of one-half of the shoe pitch and putting a new set of sprocket teeth in engagement with the pins. Life of the sprockets is thus doubled.

The lower strand of the track is supported on a series of rollers which are journalled in the longitudinal crawler frame. These rollers engage a hardened track on each side of the shoe and are spaced longitudinally so that there can be no tendency for the shoes to jack-knife. This also assures each shoe carrying its proportional share of the load.

Lateral guides are provided for the track by wear-resisting slide plates mounted on the crawler frame. Lugs, cast integral with the crawler shoes, contact these wearing bars and keep the lower



strand of the track in alignment at all times. These lugs are sufficiently high to prevent lateral displacement of the track even though the track should sag when the machine is travelling over uneven terrain. The upper strand of the crawler track is supported on the slide rails which bear on the same section of the shoe as the lower rollers. This prevents undue sag in the upper strand.

Frames are welded high tensile strength steel and are bolted to the main section of the car body so that they can be removed when necessary to keep the entire unit within shipping clearance. The car body also is welded, with the main cylindrical section of the car body and the axles combined into one integral unit. In this type of construction the bearings for the drive shafts are all carried in a single unit which is machined in one setting of the part in the machine or fixture. This method of construction and fabrication insures perfect alignment of parts thus assuring maximum performance.

Ingenuity Simplifies Designs

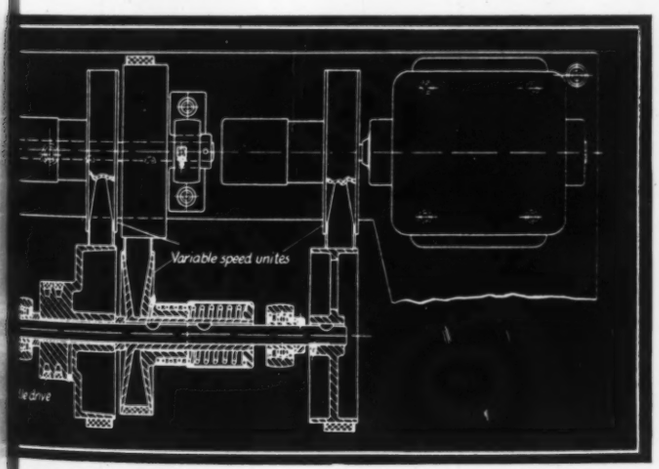
Standard Parts Provide Economical Drive

By L. D. Tyson

Chief Engineer
Foster Machine Co.

TO PROVIDE a large speed range for a superfinishing machine, its drive is designed to incorporate three vari-speed units in series. Each has a speed range up to a ratio of 3 to 1. Thus compounding them as shown in the drawing gives a maximum 27 to 1 overall ratio.

The motor carrying one of the units and a countershaft carrying another are set in line. A second countershaft carrying the third unit and the take-off to the spindle is mounted in a yoke suspended beneath the headstock of the machine in such a manner that the center distances between the two pulley groups can be changed.



Speed change is accomplished by a handwheel and screw operating on a fork or arm which controls the swinging movement of the yoke. This handwheel and screw are provided with a planetary gear speed-indicating device. By movement of the wheel all three of the units are gradually increased or decreased in ratio as the case may be. Consequently a dial can be calibrated to show the output speed at any given point.

The method thus adopted accomplishes the purpose of providing a simple, vari-speed drive with a ratio beyond anything readily obtained by other methods and, at the same time, at a moderate cost.

Utilizes Flexible Linkages

By W. C. Sutton

Engineer
Lindsay Wire Weaving Co.

TWO problems involving power transmission in the design of a machine have been solved by the use of a simple device which is seldom considered by designers as suitable for continuous operation.

In one case it is required to provide intermittent oscillating movement independently to two small levers. They are mounted on a common shaft that is adjustable axially through a considerable range. The driver is a camshaft about three feet distant, with several intervening obstructions that prevent any form of straight line connection. The utilization of a heavy type of Bowden wire or "choke control," solved this problem. Simple end fittings are used as illustrated, the important function of which is to avoid bending the operating wire at the end of the casing. In this particular case the wire is loaded in compression. Greater forces with a longer stroke may be transmitted if the wire can be kept in tension. Extreme pressure oil or worm gear lubricant are best for the lubri-

(Continued on Page 62-S)

Selecting Specia

Part IV—Multispeed Induction Motors

By J. H. Fortenbach
Induction Motor Eng. Dept.
General Electric Co.

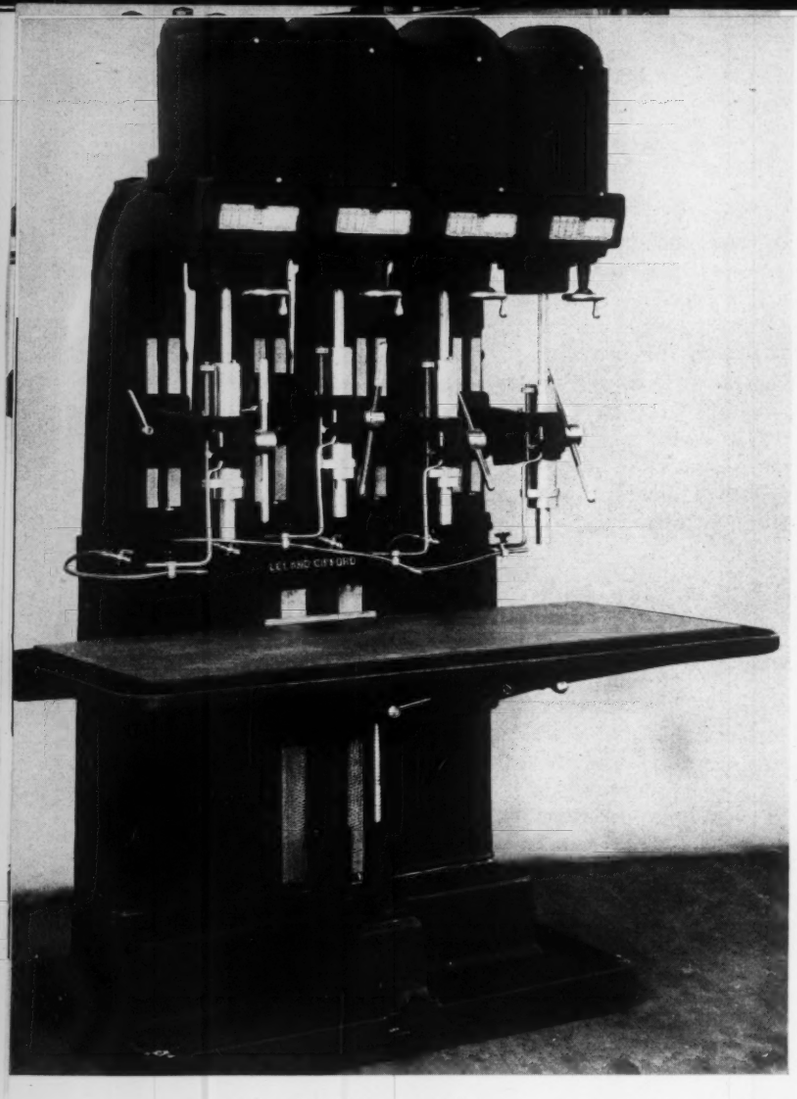


Fig. 1—Individually motorized drill spindles utilize 4-speed, constant-torque motors which are totally enclosed and fan cooled. A built-in pole changing switch is used with overload, undervoltage protection

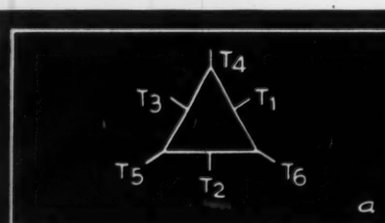
SQUIRREL-CAGE polyphase induction motor is the preferred drive in industry because of its low cost, freedom from trouble and maintenance, ease of control and the economics in distribution of alternating-current power. While its speed is normally constant the development of the multispeed form gives it a useful measure of flexibility. Although the speed of operation of this type of motor cannot be continuously varied over a wide range as in the case of a direct-current motor, it can be built to operate at a number of fixed speeds. In practice these speeds usually are limited to four.

The multispeed, squirrel-cage induction motor is similar in characteristics, then, to a shunt-wound direct-current motor with the controller arranged so that it will operate only at a few definitely fixed speeds.

Although the polyphase multispeed motor does not have the continuously varying speed characteristic of the shunt-wound direct-current motor it still has many fields of useful applications where the single-speed induction motor would require elaborate mechanical devices in the drive to obtain different speeds.

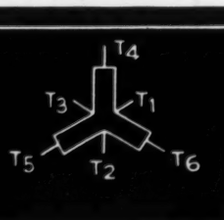
In its most rudimentary form, the multispeed motor resembles two complete motors coupled in tandem, each operated with the other idle but run-

Fig. 2—Below—Stator connections for multispeed polyphase induction motors. For three-phase, two-speed, one-winding, the connections are shown at *a* for constant horsepower, at *b* for constant torque, and at *c* for variable torque connections



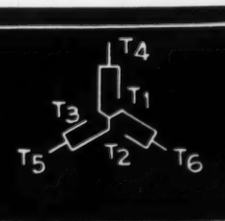
a

SPEED	L1	L2	L3	OPEN	TOGETHER
1 LOW	T1	T2	T3		T4, T5, T6
2 HIGH	T6	T4	T5	T1, T2, T3	



b

SPEED	L1	L2	L3	OPEN	TOGETHER
1 LOW	T1	T2	T3	ALL OTHERS	
2 HIGH	T6	T4	T5		T1, T2, T3



c

SPEED	L1	L2	L3	OPEN	TOGETHER
1 LOW	T1	T2	T3	ALL OTHERS	
2 HIGH	T6	T4	T5		T1, T2, T3

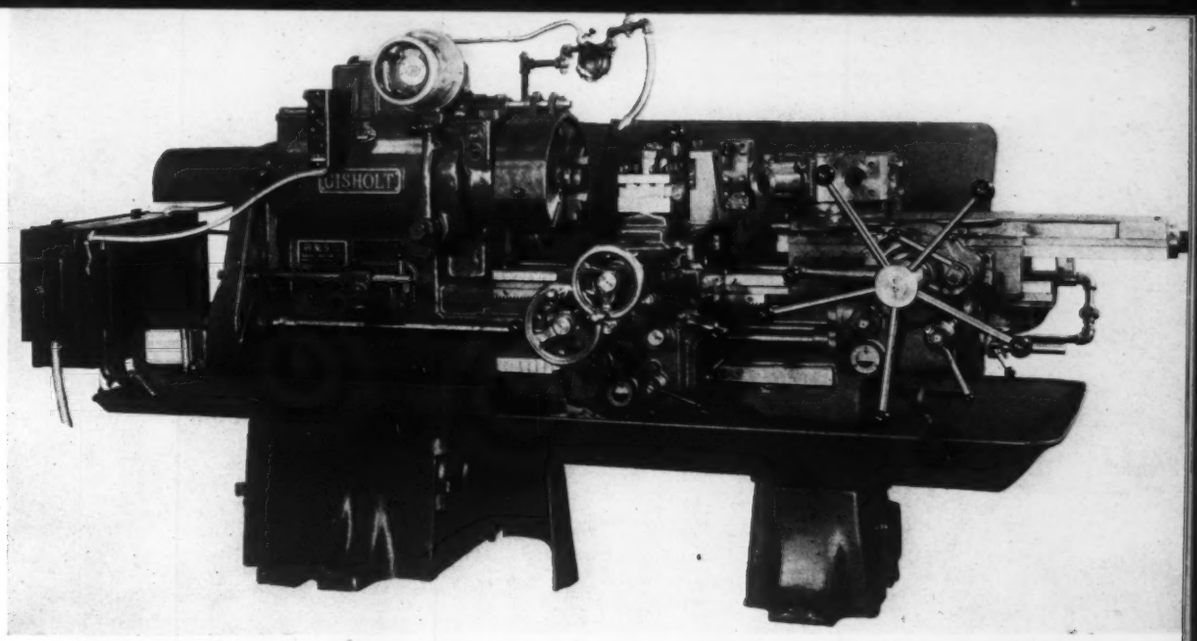


Fig. 3—Constant-torque, two-speed, single-winding motor drives spinle on this ram type turret lathe. Speed is changed by magnectic controller

ning. If two motors were used, two speeds might be chosen for 60-cycle power to be any of the synchronous speeds for this frequency such as 3600, 1800, 1200, 900, 720 and 600 revolutions per minute. In practice, however, the two motors are coalesced into one.

Inasmuch as wound-rotor, multispeed motors are little used, only squirrel-cage motors will be considered at this point of the discussion. From a practical point of view, a multispeed induction motor seldom can have more than four speeds. The reasons for this are as follows:

First, although motors have been built with four stator windings, it usually is not practical to make a multispeed induction motor which will meet a machinery manufacturer's requirements with more than two stator windings because of cost, space, performance, and reliability limitations. Second, it is not practical to make a single primary winding induction motor with more than two speeds because of the large number of stator winding leads which must be brought out to the terminal board for reconnecting from one speed to the other. This large number of stator leads makes the cost of the motor control prohibitively high. For this same reason, it is practical to make a single stator winding only for speeds which have a speed ratio of 2:1. So, with only two stator windings available per motor and with only two speeds for each winding, not more than four speeds are practical in one motor.

Speed of a squirrel-cage induction motor depends upon the number of poles for which the stator winding is wound and the frequency of the power supply. For 60 cycles, RPM = 7200 ÷ number of poles. For 25 cycles, RPM = 3000 ÷ poles. Following is a table of available speeds developed from these equations.

Fig. 4—Below—Connections for two-speed motors. At *a* is shown the high speed connection with four poles, *b* is the connection for low speed with eight poles. Current flow is indicated by arrows on solid lines; flux path, by arrows on dash lines

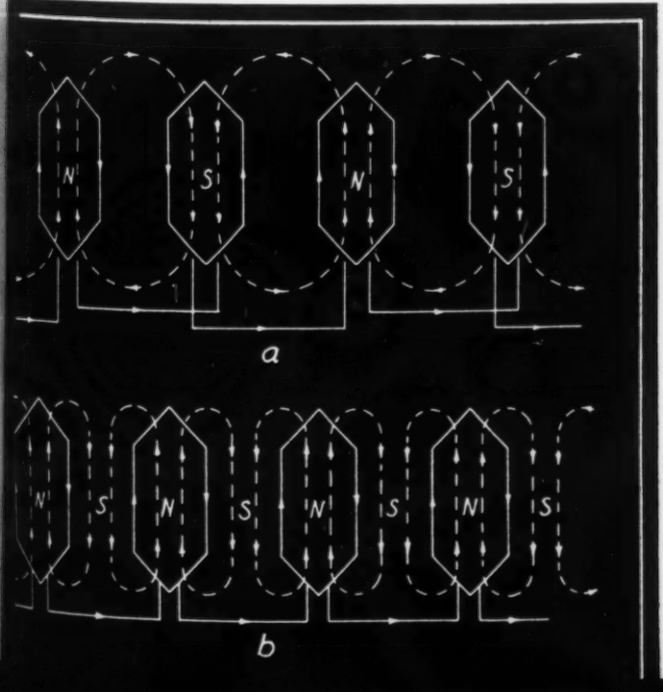


TABLE I

Relation of Number of Poles to Speed

For 60 Cycles		For 25 Cycles	
No. of Poles	**RPM**	**No. of Poles**	**RPM**
2	3600	2	1500
4	1800	4	700
6	1200	6	500
8	900	8	375
10	720	12	250
12	600		

Examples of some speed and pole combinations in four-speed motors for 3-phase 60-cycle power supply are listed in TABLE II.

The following shows how all three-phase multispeed motors may be classified according to the number of speeds and number of stator windings on the basis that not more than two stator windings should be used in one motor.

1. Two speeds (2:1 ratio), single winding
2. Two speeds, two windings
3. Three speeds, two windings
4. Four speeds, two windings.

In the three-speed motor, two of the speeds must have a 2:1 ratio. In the four-speed motor,

the two sets of speeds must each have a 2:1 ratio.

Two-phase power supply somewhat handicaps the use of multispeed motors. It is hardly ever practical to make a two-phase motor with more than two speeds because each speed should have a separate stator winding. Two-phase, two-speed, single-winding motors have been made but the inherent electrical characteristics are so poor that it is much better to use two independent stator windings.

It might be well, at this point, to consider the limitations on the horsepower ratings of multispeed motors. Obviously, the two complete motors coupled in tandem could each be built for any horsepower output required. The same is true when two stator windings are built into one machine which utilizes a common rotor. For purposes of standardization, industry recognizes three

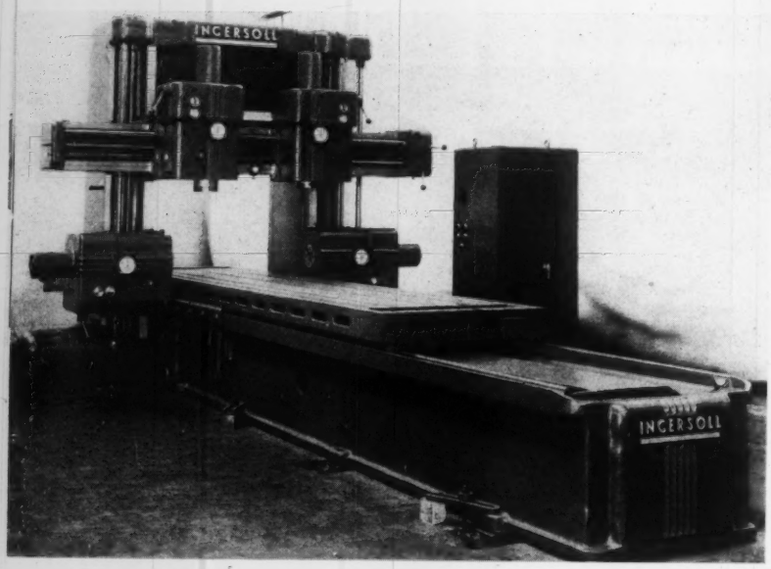


Fig. 5—Milling machine driven by 7½-horsepower 1800/1200/900/600 R.P.M. constant-torque motor for table feed. Speed is selected by pole changing switch in side of controller cabinet

varieties of ratings for multispeed motors. These varieties are constant-horsepower, constant-torque and variable-torque, and are compared in TABLE III.

Machine designers will recognize the constant-horsepower motor as the one used for the drive which does the work, such as the cutting drive on a lathe. This drive calls for the same horsepower at all speeds because in general the horsepower is proportional to the cubic inches of metal cut and because, in general, slower speeds call for proportionally larger cuts. Typical applications are shown in *Figs.* 1, 3 and 5.

The constant-torque motor will be recognized as the one used, for instance, on feed drives where, in general, the torque required is the same for all speeds and the horsepower is directly proportional to the speed.

The variable-torque motor is commonly used for pumps, fans and similar applications.

The stator winding connections of the three-phase, single-winding, two-speed motor for the constant-horsepower, constant-torque, and varia-

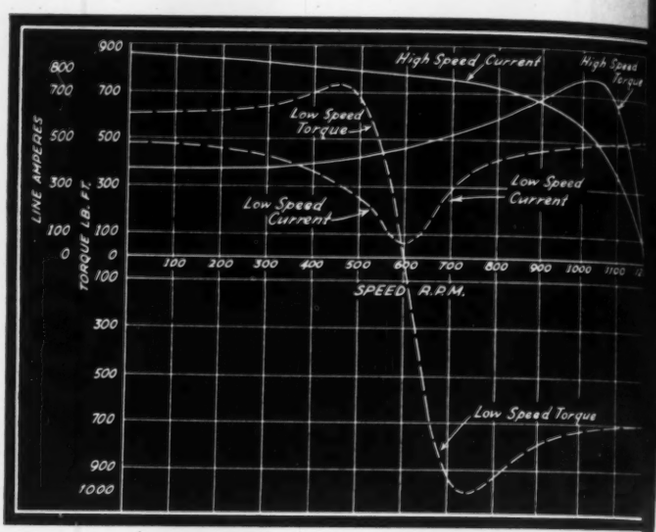


Fig. 6—Approximate speed-torque and speed-current curves for a 50/25 horsepower, 1200/600 RPM, 220-volt induction motor

ble-torque varieties are shown by *Fig.* 2. For these motors, approximate relative maximum torque outputs are given in TABLE IV.

TABLE II

Typical Speed Combinations for 3 Phase

	No. of Poles	Revolutions per Minute
1	2/4/6/12	3600/1800/1200/600
2	4/6/8/12	1800/1200/900/600
3	6/8/12/16	1200/900/600/450

The principle of the polyphase, two-speed, single-winding motor which has a 2:1 speed ratio is simple. The speed of an induction motor is inversely proportional to the number of poles for which the stator winding is wound. Two speeds can be obtained from one stator winding, if by reconnecting it, the number of poles of the stator winding is doubled. The reconnected speed is one-half of the original speed. As a motor usually is wound with half north and half south poles, the number of poles can be effectively doubled if half of the poles are reversed. The result is a winding having all wound poles of like polarity and consequent poles of opposite polarity appearing between the wound poles.

In *Fig.* 2, the low-speed connections are so placed that the currents which flow through the winding cause all the wound poles to have the same polarity. Hence, the effective number of poles is doubled and the speed of the rotating field is halved.

(*Continued on Page* 78-S)

Perforated Disk Controls Sequence

Fig. 1—Automatic unit at right of washer utilizes perforated disk to control operations

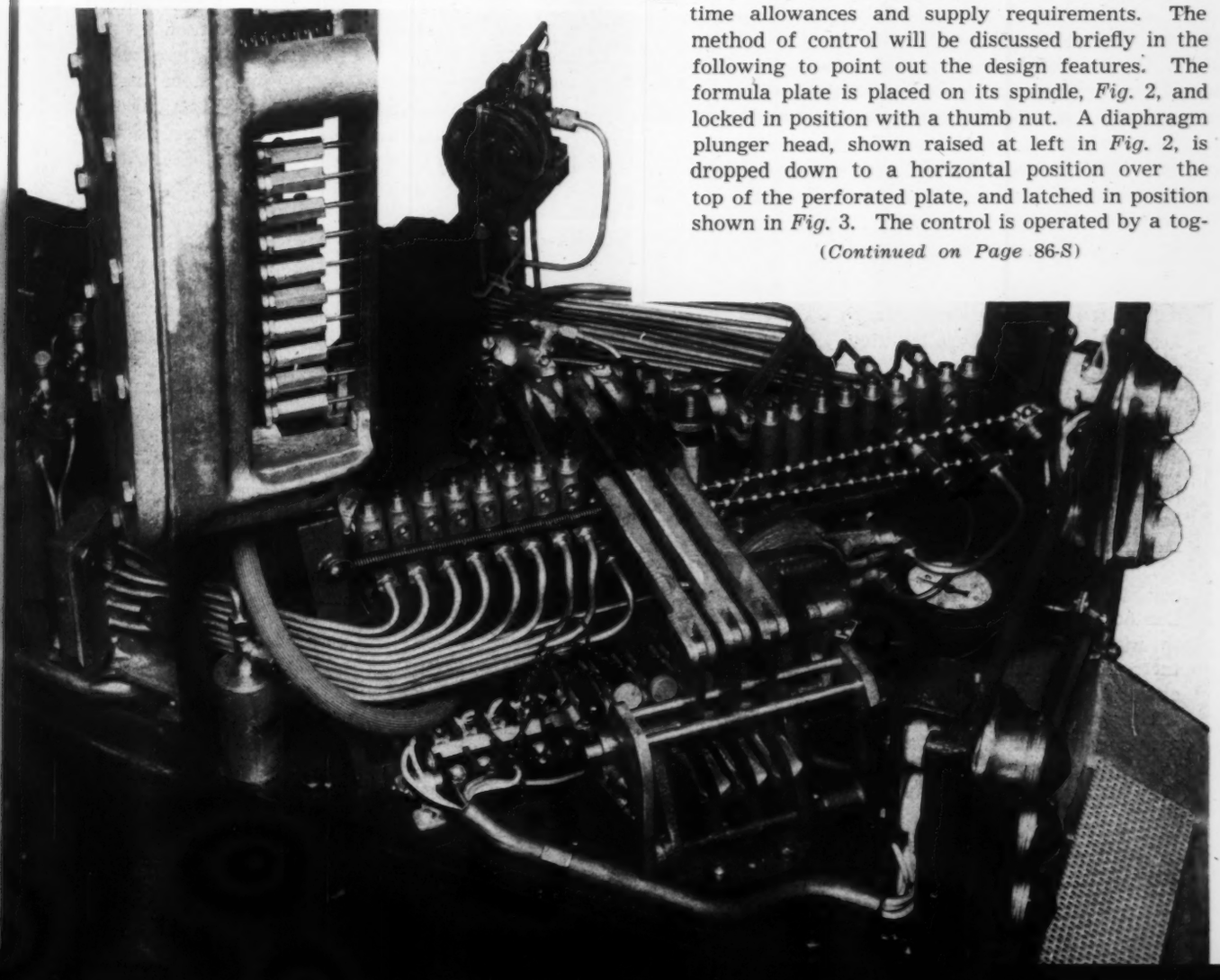
Fig. 2—Rear view of control unit with panels removed to show arrangement of air cylinders, steam tubes, syphon, valves

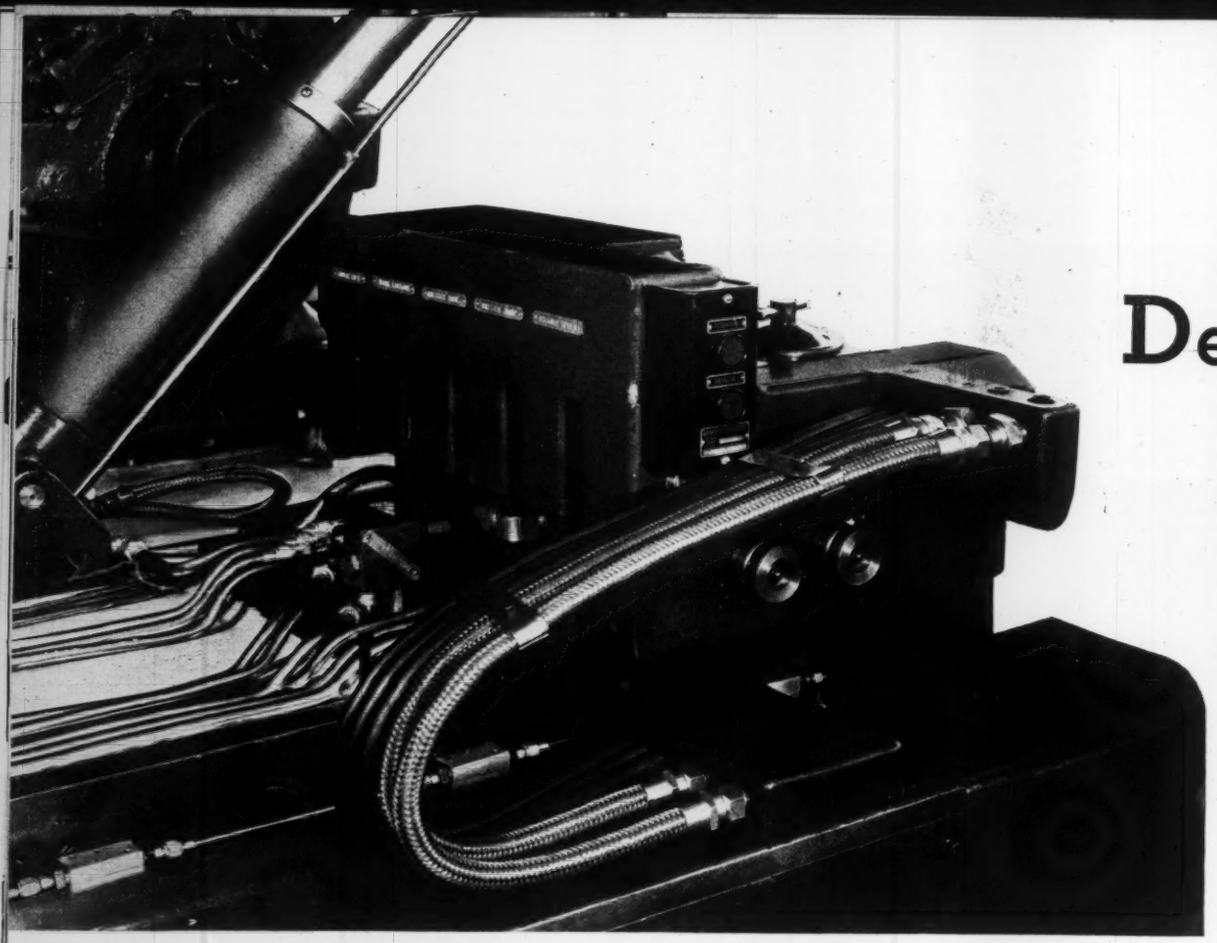
MECHANIZATION of production is a principal problem facing designers of machines for quantity output at low unit cost. Aiming at a solution of this problem with respect to professional laundries. The American Laundry Machinery Co. developed a mechanical control to take its machines through an entire washing cycle without manual operation of any functions except loading and unloading.

Utilization of a perforated brass formula plate in the control unit shown in *Fig.* 1 governs the entire cycle according to the formula plate in use. In this way 59 manual operations are eliminated in each cycle, substituting mechanical control at precisely the right time for such operations as changing water, setting water levels, introducing supplies and regulating important temperatures.

Perforated on an aluminum fixture, the circular formula plate controls valves in accordance with time allowances and supply requirements. The method of control will be discussed briefly in the following to point out the design features. The formula plate is placed on its spindle, *Fig.* 2, and locked in position with a thumb nut. A diaphragm plunger head, shown raised at left in *Fig.* 2, is dropped down to a horizontal position over the top of the perforated plate, and latched in position shown in *Fig.* 3. The control is operated by a tog-

(*Continued on Page* 86-S)





Designing C

Part II—Con rit

By R. S. Elberty
Electrical Engineer
Landis Tool Co.

Fig. 9—Electrical control of hydraulic motions involves six solenoid valves on wheel base of grinder

ABILITY of a machine to function correctly may be determined by reducing the machine to a chain of links and pairs and applying the criterion of restraint to determine whether it has enough, too many, or too few members. Likewise, the machine designer can use to good advantage a new criterion, the "Control Criterion" to evaluate the electric or hydraulic controls required for a machine.

While this control criterion is applicable to mechanical, hydraulic and pneumatic controls, it originally was developed for electrical control circuits. It provides a simple check on the effectiveness of even the complex control circuits required on modern machines. Applied in much the same way as the criterion of restraint, the control criterion determines if the control has enough, too many, or too few members to accomplish the desired functions of the machine. The machine designer is best qualified to apply this criterion since he best understands the machine and the requirements of the job.

Electrical control is easier to analyze if the complex forms of the devices are not considered. Contacts may be operated by various means such as magnetic, mechanical or thermal. The contacts themselves are simple in structure and serve either to open or to close a circuit. Electrical wiring carries the electrical energy to the operated members. Motors, magnets and other operated members sometimes have complicated forms, but they all serve one purpose. They usefully convert electrical energy into energy of another form. Typical conversion devices are represented by resistors, transformers, and rectifiers. These serve to change the electrical energy into more useful forms. A functional grouping of electrical devices used on machine control will therefore list only four classifications: (1) Contacts; (2) wires; (3) operated members; and (4) conversion equipment.

Operations Determine Minimum Circuits

Machine operations determine the number and type of operated members and the power supply available governs the necessity for conversion devices. While not as evident, the machine functions determine the number of contacts. In turn, the number of contacts, operated members, and conversion devices (including their arrangement on the machine) determine the number of wires to be used. The control criterion specifies a relationship between the various operations of a machine and the number of contacts necessary. Since the simplest control for a given number of functions will be the one with the least contacts, the machine designer must plan his machine to include all necessary functions and to eliminate all unnecessary ones. Before the control is designed, therefore, the various operations should be analyzed and tabulated.

Any single electrical contact furnishes two conditions—open or closed circuit. A "free contact"

ing Control Circuits

–Con iterion–A Check on Design

does not depend on the position of any other contact in the circuit. After the first free contact, each additional free contact that is added to the circuit will add one condition. To add circuit closing or starting conditions, contacts are added in parallel. For circuit opening or stopping conditions, contacts are added in series.

Applies to All Free Contacts

Free contacts form the principal type used in control circuits. Many fundamental control circuits are composed entirely of free contacts. Single pole pushbuttons, overload relays, limit switches, and single pole magnetic relays may be combined to form complete controls of the simpler types. The control criterion for free contacts may be expressed as follows:

$$F = C = N_f + 1$$

Where F = number of machine functions (electrical), C = number of conditions furnished by control, and N_f = number of contacts (free contacts only)

To show that this criterion may be applied equally to series and parallel contacts, the following considerations are developed.

SERIES CONTACTS: Assuming N contacts in series, there is one condition obtained with all contacts closed. Any contact being open will dominate all conditions obtained with other contacts being open. Because there are N conditions obtainable with one contact being open, the total conditions are $N + 1$.

PARALLEL CONTACTS: With N contacts arranged in parallel, there is one condition that can be obtained with all contacts open. Any contact being closed will dominate all conditions obtained with other contacts being closed. Since there are N conditions with one contact being closed, there are a total of $N + 1$ conditions as has been shown for the contacts in series.

SERIES-PARALLEL CIRCUITS: The foregoing method of analysis can also be applied to series-parallel circuits to show that closed contacts in parallel dominate conditions obtained from other closed contacts in parallel. Also, in

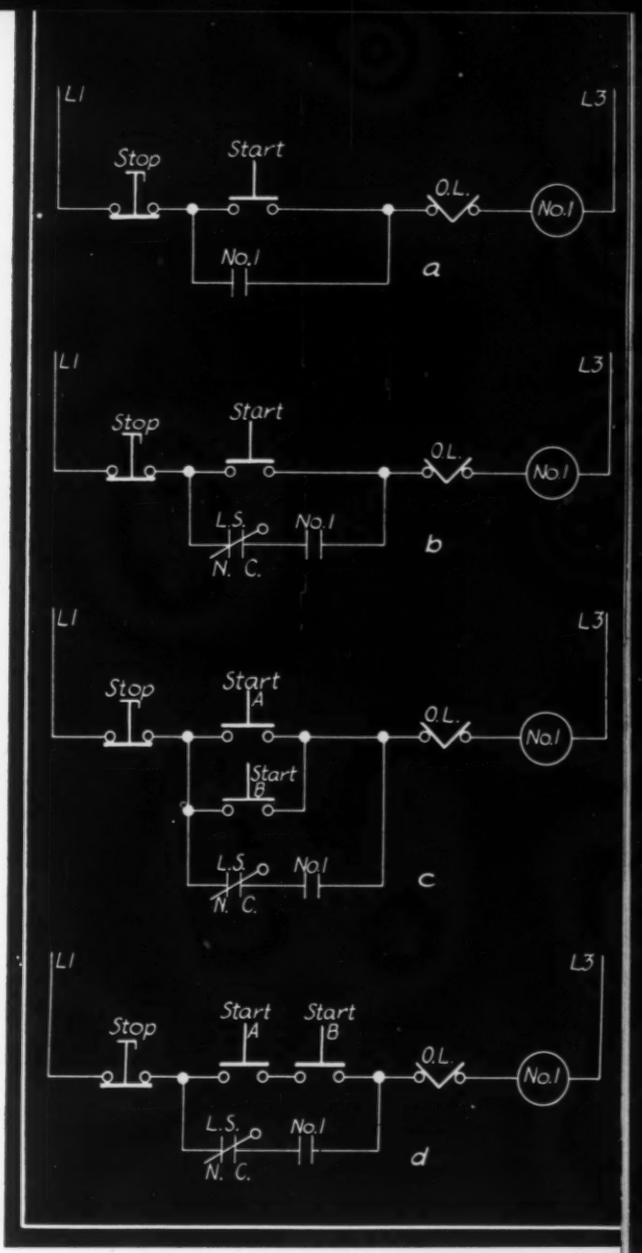


Fig. 11—Diagrams show how control criterion is applied to circuits. At *a*, five conditions are met by four contacts; a limit stop is added at *b*; start condition is added with another pushbutton in parallel at *c*; and at *d* the start buttons are connected in series

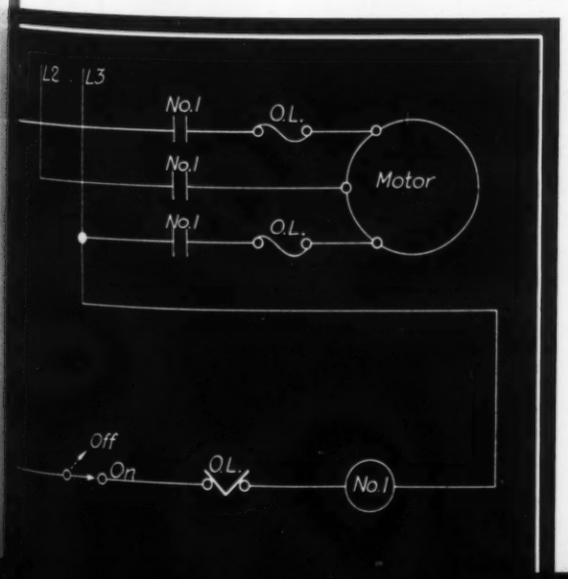


Fig. 10—Schematic diagram of common "on-off" circuit

the series part of the circuit, open contacts dominate conditions obtained from other open contacts in series.

To express this as a formula, N_s = number of series contacts and N_p = number of parallel contacts. Total conditions = $(N_s + 1)(N_p + 1) = N_s + N_p + N_sN_p + 1$ conditions. For a parallel circuit in series with a series circuit N_sN_p conditions will be dominated by N_s conditions and the net conditions available will be $N_s + N_p + 1$. For a series circuit in parallel with a parallel circuit, N_sN_p conditions will be dominated by N_p conditions and the total net conditions available will still be expressed by the formula $N_s + N_p + 1$ which again is an expression of the control criterion.

Examples Illustrate Applications

Examples of applications of the criterion to a single motor circuit with overload protection should start with the common "on-off" circuit using a selector switch as illustrated in *Fig.* 10. Conditions are "on," "off" and "overload." These three conditions are supplied with two contacts and the control criterion is satisfied for this particular circuit.

To add low voltage protection to this control as shown in the schematic diagram, *Fig.* 11*a*, the

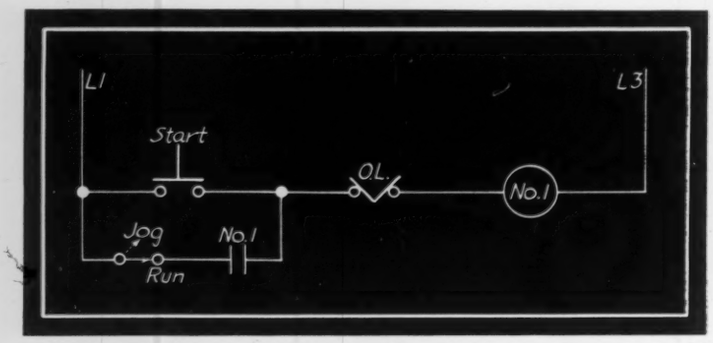


Fig. 12—Stop button in fundamental control circuit replaced by selector switch for jog operations.

conditions are now "start," "stop," "run," "overload" and "low voltage." These five conditions are furnished by the four contacts and the criterion is satisfied. This circuit now forms a foundation for most control diagrams. For example to add a "limit stop" condition, a limit switch is added in series with No. 1 interlock, *Fig.* 11*b*. A "start" condition from another station or point of the control may be added by adding another start button in parallel with the first, *Fig.* 11*c*. If it is required to depress both start buttons in order to start, both start buttons are connected in series as in *Fig.* 11*d*.

These examples show how conditions are increased by the addition of contacts and illustrate the rule that contacts for starting conditions are added in parallel and contacts for stopping conditions are added in series. Each example also satisfies the control criterion for free contacts, $F = C = N_f + 1$. If contacts are located differently the conditions of the control may be changed, but the number of conditions will remain the same and the control criterion will be satisfied. For instance, the stop button in the fundamental control circuit may be replaced by a selector switch placed in series with the No. 1 interlock, see *Fig.* 12. The conditions are now "jog," "run," "stop," "overload" and "low voltage." The control criterion is satisfied but the start condition in the original control has been replaced by the new jog condition.

Can Simplify Wiring

Once a workable control has been designed, the contacts can be located on the diagram to simplify the wiring of the machine. All contacts that are close together on the machine, should be located as closely together as possible on the elementary diagram. The control criterion shows that nothing can be gained by locating contacts on both sides of the operated members.

Good control practice will connect all operated members to the right-hand line of the schematic diagram. Since contacts on the panel are located close to most operated members, they should be as close as possible on the functional diagram. Pushbuttons and selector switches are close together on a machine and the functional diagram should group them at the left-hand line of the diagram. Other contacts such as limit and timer switches can be placed between the manually operated contacts and the contacts mounted on the panel.

Produces Simple and Safe Control

Such a logical arrangement of the electrical parts on the elementary diagram will tend to produce automatically a simple and safe control. Contacts can be relocated in the final revision of the diagram to simplify the wiring of the machine. If the control criterion is satisfied, no further reduction of the number of contacts is possible without a reduction in the machine functions. With a clear cut layout of the wiring, the machine designer can be sure that the control design is off to a good start.

Part III, in the next issue, will conclude this discussion on designing electrical control circuits. Restraint of electric contacts as well as special applications of the control criterion will be covered. Also, apparent exceptions to the criterion will be pointed out and identified.

Use New V-Belt Ratings for Economical Drive

By E. A. Gahl
Allis Chalmers Mfg. Co.

NEW V-belt ratings, recently adopted by V-belt manufacturers, are of considerable importance to design engineers because they take into consideration two important factors: Belt speeds and sheave diameters. Furthermore, the disadvantages of using small diameter sheaves is particularly emphasized in the new ratings.

Good engineering requires not only the selection of suitable sheave ratios and economical centers, but also consideration of other factors such as first cost, upkeep and replacement. While V-belt drives are primarily a comparatively high speed drive, such advantages as quietness, shock absorbing qualities, cleanliness and general adaptability have made them practical for almost every kind of machine. Refrigerator compressors, automobile fans, furnace fans and automatic water pumps comprise the simplest applications usually using

TABLE I

Horsepower Ratings for A-Section V-Belts

(½ to 5 HP., 40 Lbs. Belt Tension)

Velocity in Ft./Min.	Pitch Diameters						
	2.6"	3.0"	3.4"	3.8"	4.2"	4.6"	5.0" & larger
1000	.5	.7	.8	.9	.9	1.0	1.0
1100	.6	.7	.9	1.0	1.0	1.1	1.1
1200	.6	.8	1.0	1.0	1.1	1.2	1.2
1300	.7	.9	1.0	1.1	1.2	1.3	1.3
1400	.7	.9	1.1	1.2	1.3	1.4	1.4
1500	.8	1.0	1.1	1.3	1.4	1.4	1.5
1600	.8	1.0	1.2	1.3	1.4	1.5	1.6
1700	.9	1.1	1.3	1.4	1.5	1.6	1.7
1800	.9	1.2	1.4	1.5	1.6	1.7	1.8
1900	.9	1.2	1.4	1.6	1.7	1.8	1.9
2000	1.0	1.3	1.5	1.6	1.8	1.9	2.0
2100	1.0	1.3	1.5	1.7	1.9	2.0	2.1
2200	1.1	1.4	1.6	1.8	1.9	2.0	2.2
2300	1.1	1.4	1.6	1.8	2.0	2.1	2.3
2400	1.1	1.4	1.7	1.9	2.0	2.2	2.3
2500	1.1	1.5	1.7	2.0	2.1	2.3	2.4
2600		1.6	1.8	2.0	2.2	2.3	2.5
2700		1.6	1.8	2.1	2.3	2.4	2.6
2800		1.6	1.9	2.1	2.3	2.5	2.6
2900		1.6	1.9	2.2	2.4	2.6	2.7
3000			2.0	2.2	2.4	2.6	2.7
3100			2.0	2.3	2.5	2.6	2.8
3200			2.0	2.3	2.5	2.7	2.9
3300			2.1	2.4	2.6	2.7	2.9
3400				2.4	2.7	2.8	3.0
3500				2.5	2.7	2.8	3.0
3600				2.5	2.7	2.9	3.1
3700				2.5	2.8	2.9	3.1
3800					2.8	3.0	3.2
3900					2.8	3.0	3.2
4000					2.8	3.0	3.3
4100					2.9	3.1	3.3
4200						3.1	3.3
4300						3.1	3.3
4400						3.2	3.4
4500						3.2	3.4
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4700							3.4
4800							3.4
4900							3.4
5000							3.4

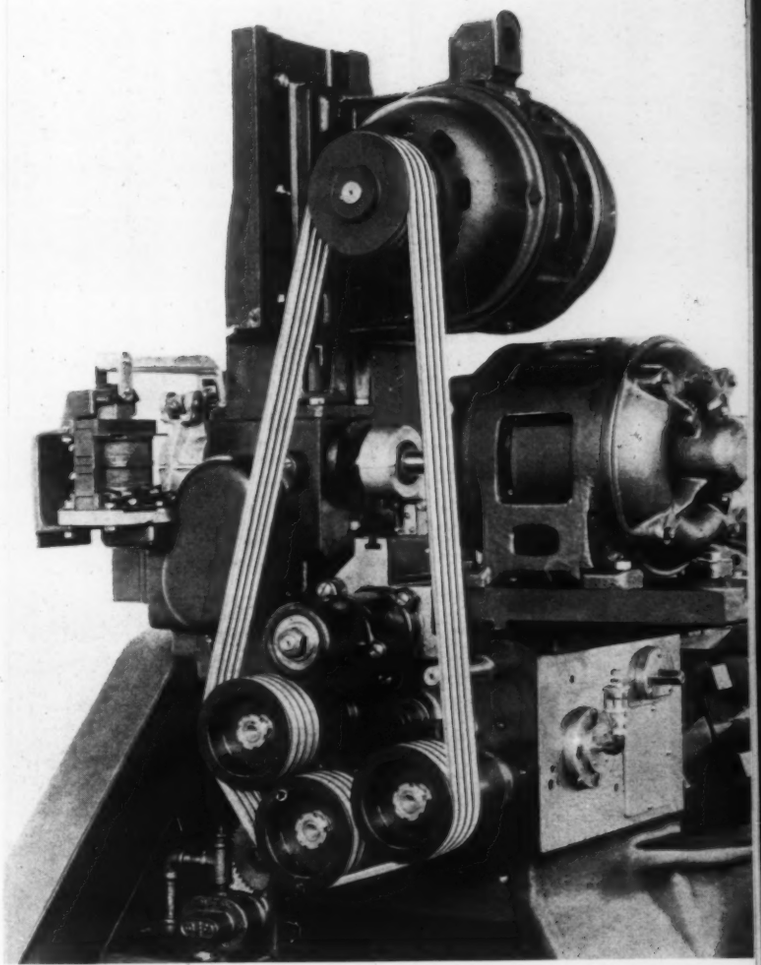


Fig. 1—Multiple-spindle automatic machine incorporates compactness and accessibility in its drive. Short contact arcs of belt require careful application.

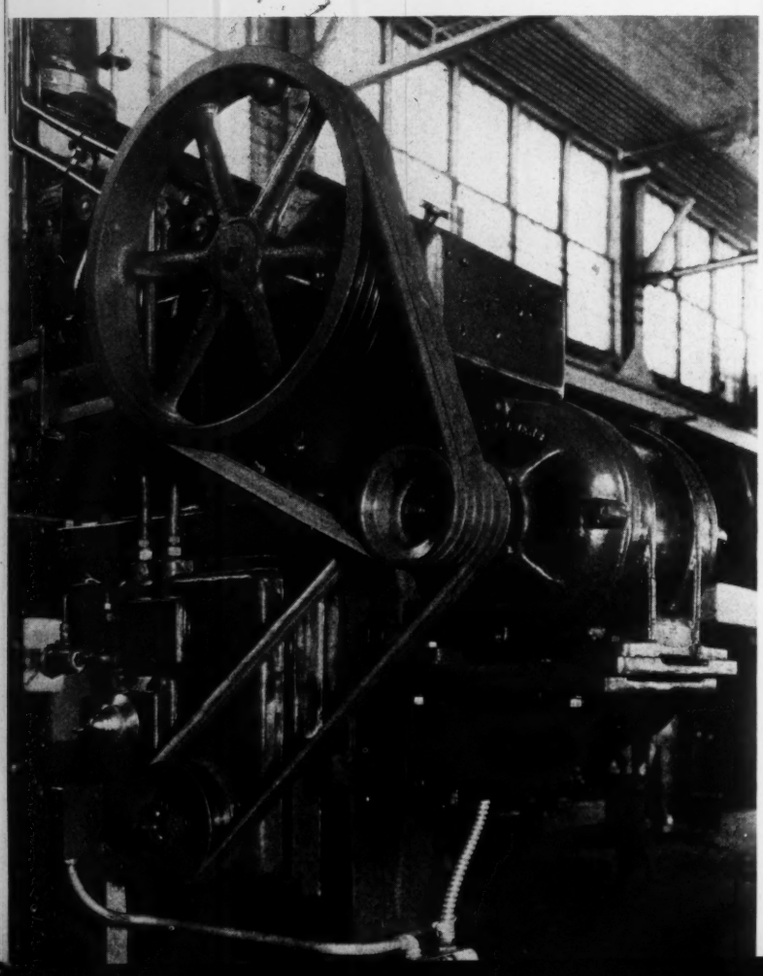
TABLE II

Horsepower Ratings for B-Section V-Belts

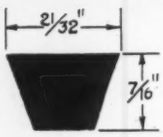
(2 to 25 HP., 70 Lbs. Belt Tension)

Velocity in Ft./Min.	Pitch Diameters					
	5.0"	5.4"	5.8"	6.2"	6.6"	7.0" & Larger
1000	1.3	1.4	1.5	1.6	1.7	1.8
1100	1.4	1.5	1.6	1.7	1.8	1.9
1200	1.5	1.6	1.7	1.8	1.9	2.0
1300	1.6	1.8	1.9	2.0	2.1	2.2
1400	1.7	1.9	2.0	2.1	2.2	2.3
1500	1.8	2.0	2.1	2.3	2.4	2.5
1600	1.9	2.1	2.3	2.4	2.5	2.6
1700	2.0	2.2	2.4	2.5	2.7	2.8
1800	2.2	2.4	2.5	2.7	2.8	2.9
1900	2.3	2.5	2.6	2.8	3.0	3.1
2000	2.4	2.6	2.8	2.9	3.1	3.2
2100	2.4	2.7	2.9	3.1	3.2	3.4
2200	2.5	2.8	3.0	3.2	3.4	3.5
2300	2.6	2.9	3.1	3.3	3.5	3.6
2400	2.7	3.0	3.2	3.4	3.6	3.7
2500	2.8	3.1	3.3	3.5	3.7	3.9
2600	2.9	3.2	3.4	3.6	3.8	4.0
2700	3.0	3.3	3.5	3.7	3.9	4.1
2800	3.0	3.3	3.6	3.8	4.1	4.3
2900	3.1	3.4	3.7	3.9	4.2	4.4
3000	3.2	3.5	3.8	4.0	4.3	4.5
3100	3.2	3.6	3.9	4.1	4.4	4.6
3200	3.3	3.6	4.0	4.2	4.5	4.7
3300	3.3	3.7	4.0	4.3	4.6	4.8
3400	3.4	3.7	4.1	4.4	4.7	4.9
3500	3.4	3.8	4.1	4.4	4.7	4.9
3600	3.4	3.8	4.2	4.5	4.8	5.0
3700	3.5	3.9	4.3	4.5	4.8	5.1
3800	3.5	3.9	4.3	4.6	4.9	5.2
3900	3.5	3.9	4.3	4.6	4.9	5.2
4000	3.5	4.0	4.4	4.7	5.0	5.3
4100	3.5	4.0	4.4	4.7	5.0	5.3
4200	3.5	4.0	4.4	4.7	5.1	5.4
4300	3.5	4.0	4.4	4.7	5.1	5.4
4400	3.5	4.0	4.4	4.8	5.1	5.4
4500	3.5	4.0	4.4	4.8	5.1	5.4
4600	3.4	4.0	4.4	4.8	5.1	5.5
4700	3.4	3.9	4.4	4.8	5.2	5.5
4800	3.4	3.9	4.4	4.8	5.2	5.5
4900	3.3	3.9	4.3	4.8	5.1	5.5
5000	3.3	3.8	4.3	4.7	5.1	5.5

Fig. 2—Hydraulic feed drill utilizes V-belts to advantage for both hydraulic and mechanical drives



V-belts. Heavy machinery such as rock crushers, hammer mills, paper mill beaters, lumber mills and air compressors are a few of the many larger types of applications. Other applications for which these drives are particularly suitable are shown in *Figs.* 1, 2 and 3. Belt speeds from 1000 feet per minute up to 5000 feet per minute are particularly recommended, when used with sheaves of proper diameters.



During the past year, belt ratings were revised to recognize application factors. Emphasis is no longer given to any minimum sheave diameter, but to all diameters for a given horsepower and belt speed. By encouraging the use of larger diameter sheaves, the reduced belt flexing and higher speeds permits increasing the belt ratings.

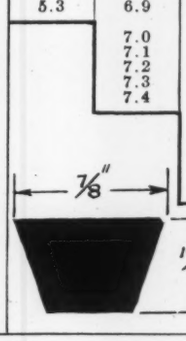
The new V-belt drive ratings given in TABLES I, II, III, IV and V show the horsepower obtainable at definite belt velocities for the various diameters of sheaves used with each of the standard belt sizes. In the head of each table is indicated the range of horsepower rating for which the particular belt section is recommended, whether in a single or multiple belts. These tables have been developed

TABLE III

Horsepower Ratings for C-Section V-Belts

(15 to 100 HP., 125 Lb. Belt Tension)

Velocity in Ft./Min.	Pitch Diameters					
	7.0"	8.0"	9.0"	10.0"	11.0"	12.0" & Larger
1000	2.0	2.5	2.8	3.1	3.4	3.6
1100	2.2	2.7	3.1	3.5	3.7	3.9
1200	2.4	2.9	3.4	3.8	4.0	4.3
1300	2.6	3.2	3.7	4.1	4.4	4.6
1400	2.7	3.4	3.9	4.4	4.7	5.0
1500	2.9	3.6	4.2	4.6	5.0	5.3
1600	3.1	3.9	4.5	4.9	5.3	5.7
1700	3.3	4.1	4.7	5.3	5.6	6.0
1800	3.4	4.3	5.0	5.5	5.9	6.3
1900	3.6	4.5	5.2	5.8	6.2	6.6
2000	3.7	4.7	5.5	6.1	6.5	7.0
2100	3.9	4.9	5.7	6.3	6.8	7.3
2200	4.0	5.1	5.9	6.6	7.1	7.6
2300	4.2	5.3	6.2	6.8	7.4	7.9
2400	4.3	5.5	6.4	7.1	7.7	8.2
2500	4.5	5.7	6.6	7.3	8.0	8.5
2600	4.6	5.8	6.8	7.6	8.2	8.8
2700	4.7	6.0	7.0	7.8	8.4	9.0
2800	4.8	6.2	7.2	8.0	8.7	9.3
2900	4.9	6.3	7.4	8.3	9.0	9.6
3000	5.0	6.5	7.6	8.5	9.2	9.8
3100	5.1	6.6	7.8	8.7	9.5	10.1
3200	5.2	6.7	7.9	8.9	9.7	10.3
3300	5.3	6.9	8.1	9.1	9.9	10.6
3400		7.0	8.3	9.3	10.1	10.8
3500		7.1	8.4	9.4	10.3	11.0
3600		7.2	8.5	9.6	10.5	11.2
3700		7.3	8.7	9.8	10.7	11.4
3800		7.4	8.8	9.9	10.9	11.6
3900			8.9	10.1	11.0	11.8
4000			9.0	10.2	11.2	12.0
4100			9.1	10.3	11.3	12.2
4200			9.2	10.4	11.5	12.3
4300			9.3	10.5	11.6	12.5
4400				10.6	11.7	12.6
4500				10.7	11.8	12.7
4600				10.8	11.9	12.9
4700				10.8	12.0	13.0
4800				10.9	12.1	13.3
4900					12.1	13.2
5000					12.2	13.2



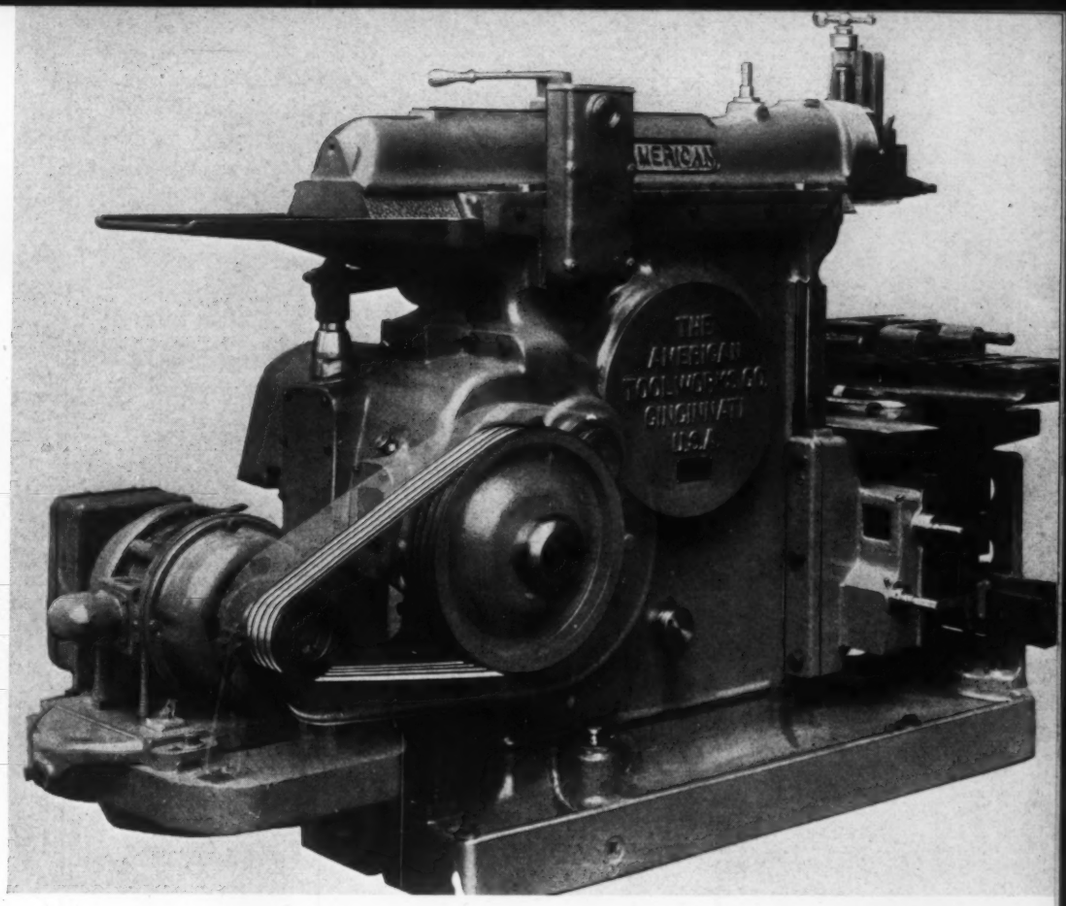


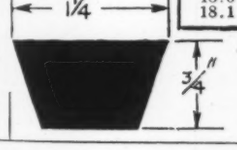
Fig. 3—Efficient and quiet drive is obtained on shaper with V-belts

TABLE IV

Horsepower Ratings for D-Section V-Belts

(50 to 250 HP., 230 Lb. Belt Tension)

Velocity in Ft./Min.	Pitch Diameters					
	12.0"	13.0"	14.0"	15.0"	16.0"	17.0" & Larger
1000	4.5	5.1	5.6	6.1	6.5	6.8
1100	4.9	5.8	6.2	6.7	7.2	7.5
1200	5.3	6.1	6.7	7.3	7.7	8.2
1300	5.7	6.5	7.2	7.8	8.4	8.8
1400	6.1	7.0	7.8	8.4	9.0	9.4
1500	6.5	7.5	8.2	9.0	9.6	10.1
1600	6.9	7.9	8.8	9.5	10.2	10.7
1700	7.3	8.4	9.3	10.1	10.8	11.4
1800	7.7	8.8	9.8	10.6	11.3	12.0
1900	8.0	9.2	10.2	11.1	11.9	12.6
2000	8.4	9.7	10.7	11.7	12.5	13.2
2100	8.8	10.1	11.2	12.2	13.0	13.8
2200	9.1	10.5	11.7	12.7	13.6	14.4
2300	9.5	10.9	12.1	13.2	14.1	14.9
2400	9.8	11.3	12.6	13.7	14.6	15.5
2500	10.1	11.6	12.9	14.1	15.1	16.0
2600	10.4	12.0	13.4	14.6	15.6	16.6
2700	10.6	12.3	13.8	15.0	16.1	17.1
2800	10.9	12.7	14.1	15.5	16.6	17.6
2900	11.2	13.0	14.5	15.9	17.0	18.1
3000	11.4	13.3	14.9	16.3	17.5	18.6
3100	11.7	13.6	15.2	16.7	17.9	19.0
3200	11.9	13.9	15.6	17.1	18.4	19.5
3300	12.1	14.1	15.9	17.4	18.9	19.9
3400	12.2	14.4	16.2	17.7	19.1	20.3
3500	12.4	14.6	16.5	18.1	19.5	20.7
3600	12.6	14.8	16.7	18.4	19.8	21.1
3700	12.7	15.0	17.0	18.7	20.2	21.5
3800	12.8	15.2	17.2	18.9	20.4	22.2
3900		15.3	17.4	19.2	20.7	22.3
4000		15.5	17.6	19.4	21.0	22.5
4100		15.6	17.8	19.6	21.3	22.8
4200			17.9	19.8	21.5	23.0
4300			18.0	20.0	21.8	23.0
4400			18.1	20.1	21.9	23.3
4500				20.3	22.1	23.5
4600				20.4	22.3	23.9
4700				20.5	22.4	24.1
4800					22.5	24.2
4900					22.6	24.3
5000					22.6	24.4



from the following formula which has been adopted by the multiple V-Belt Drive Association.

$$HP/\text{belt} = \left[kT_o n - \frac{4\,E\,t n}{3\,n_i\,d} - \frac{W}{g}\left(\frac{V}{60}\right)^2\right] \cdot \frac{T_1 - T_2}{T_1 - T_c} \cdot \frac{V}{33000}$$

Where:

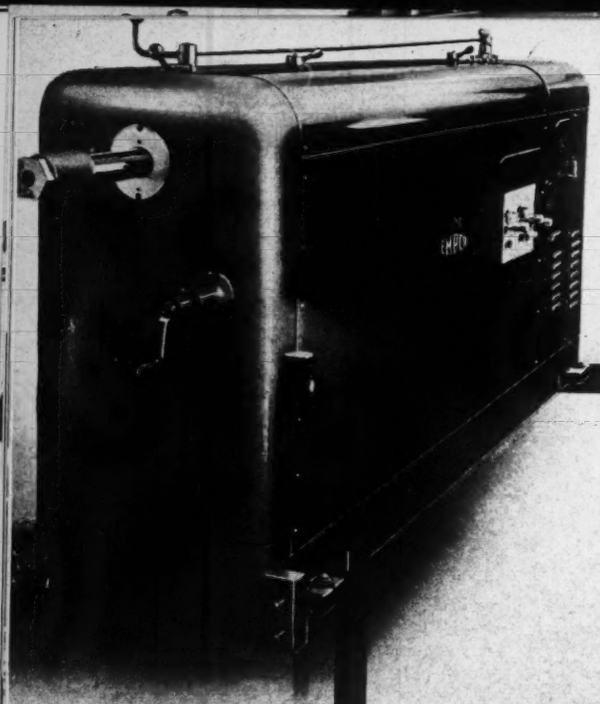
HP/belt = Horsepower recommended per belt.
k = Load safety factor.
T_o = Breaking strength of one cord.
n = Number of cords in belt.
E = Modulus of elasticity of belt cords.
t = Outer cord distance from neutral axis of cord cross-section.
$1/n_i$ = Area of one cord cross-section.
d = Diameter of small sheave.
W = Weight of belt per ft. length.
g = Gravity constant.
V = Belt velocity in ft./min.
T_1 = Belt tension on tight side.
T_2 = Belt tension on slack side.
T_c = Tension due to centrifugal force.
$kT_o n$ = Maximum allowable tension.
$\frac{4\,E\,t n}{3\,n_i\,d} = T_b$ = Bending stress term.
$\frac{W}{g}\left(\frac{V}{60}\right)^2 = T_c$ = Centrifugal force term.

The above formula in a more usable form is

$$HP/\text{belt} = \left[.33916k\,n - \frac{6.141\,t n}{d} - .209\,W\left(\frac{V}{1000}\right)^2\right] \cdot \frac{V}{1000}$$

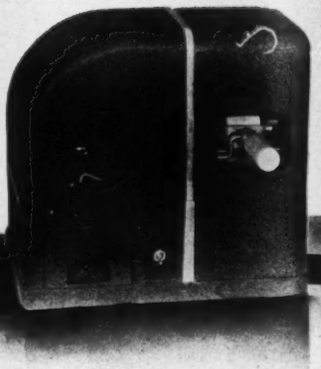
By studying the new tables it will be found that for any given belt velocity the horsepower ratings grow larger with increased diameters. This means that it is usually permissible to use fewer

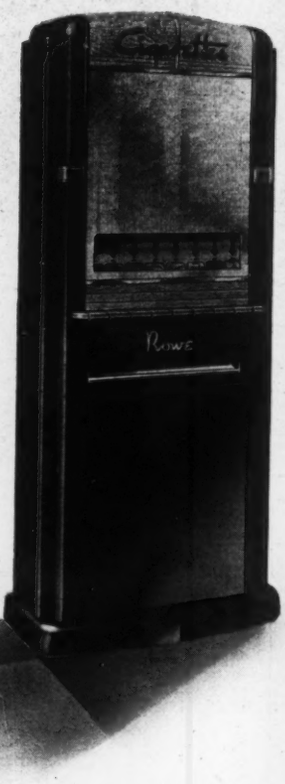
(Continued on Page 90-S)



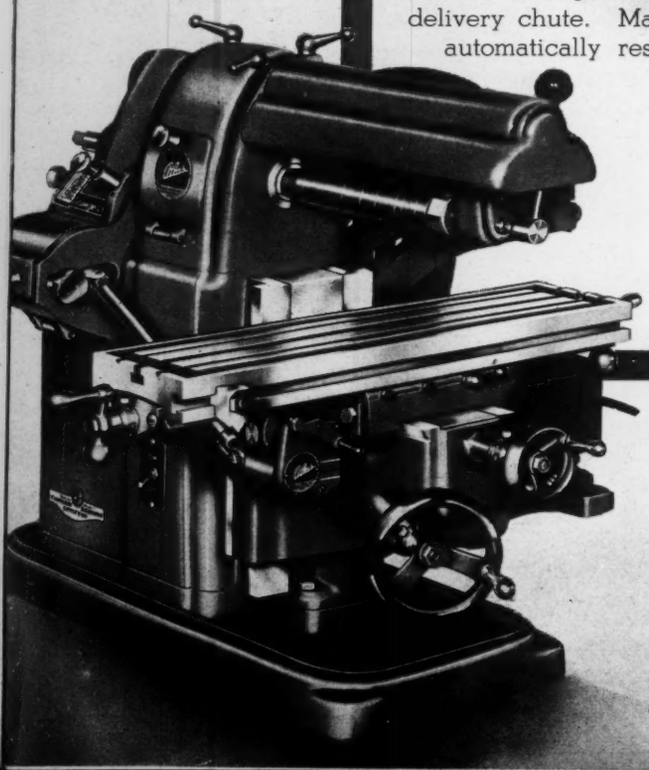
Controls of Empco honing machine (above) have been simplified and blended into machine's contours. Traverse is controlled in decimal increments to a maximum of sixty inches, on work ranging in size from two to twelve inches. A cross hatch motion of the stones is obtainable through the use of a variable speed transmission, automatically or manually controlled. All working parts of machine are enclosed

Through a roller chain drive, power is conveyed in the Markem machine (right) from a small gearmotor to a pair of automatic feed ink reservoirs and a pair of wheels holding rubber printing elements, one set for each color desired. The motor is touch-controlled by the insertion of a synthetic rubber offset roll and the machine imprints a two-color imprint in reverse on the roll





Manually operated plungers actuate Rowe cigarette merchandiser (right). When penny change-making device is used, drive bracket extending down through plunger contacts a flat spring connected to the change device shaft. This shaft turns shutter and allows pennies to fall into aperture of shutter. Upward plunger stroke then releases pennies into delivery chute. Machine automatically resets



Change-O-Matic mechanism in Atlas milling machine (left) permits instant selection of reversible automatic table feeds. By turning a knob one of four separate gear trains in the mechanism is engaged with the spindle gear, while a tumbler lever reverses direction of feed. Drive from motor to countershaft and to spindle is by V-belts. Support brackets for countershaft and motor base are attached directly to column, making machine compact

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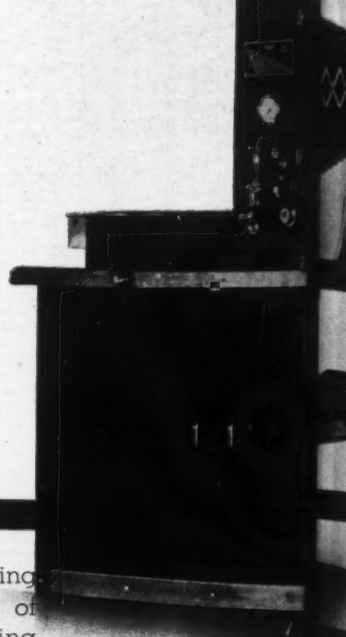
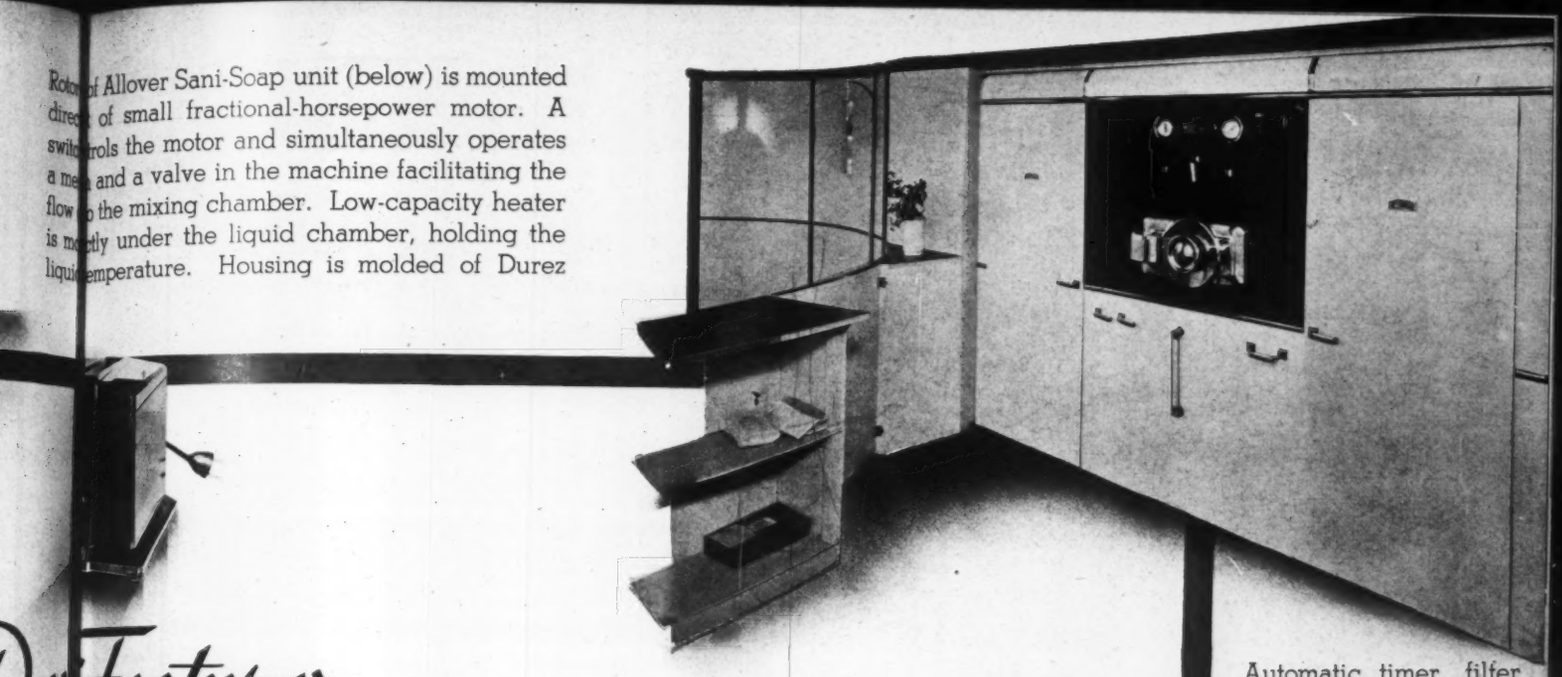


Rotor of Allover Sani-Soap unit (below) is mounted direct of small fractional-horsepower motor. A switch rols the motor and simultaneously operates a me and a valve in the machine facilitating the flow to the mixing chamber. Low-capacity heater is mo tly under the liquid chamber, holding the liqui emperature. Housing is molded of Durez



De Features
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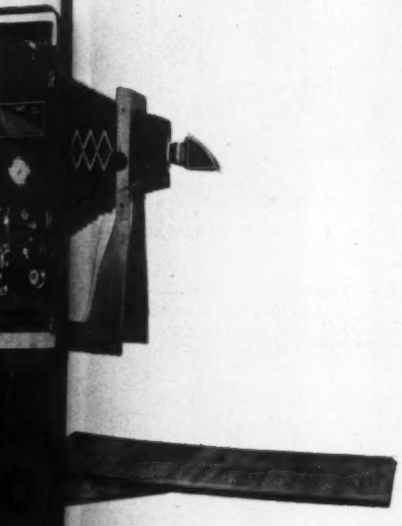

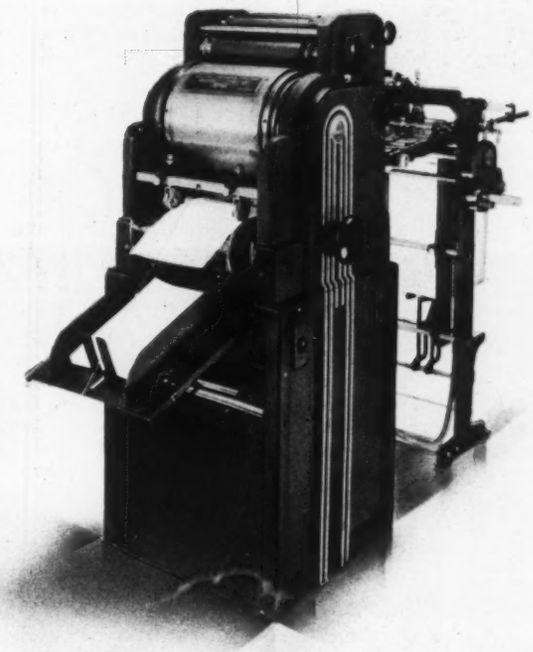

Speed of Davidson duplicator (above) is changed by moving base of driving motor, thus varying pitch of V-belt pulley. Train of gears transmits power from drive-shaft. Suction feeder has separate motor and the paper pickup mechanism is driven by a rod connected to the crank arm of the feeder and to a driving disk on a shaft in the duplicator. Conveyor tapes are also V-belt. Inking and dampening mechanisms have separate controls and an air clutch shuts off paper feed

Automatic timer, filter pressure gage, operating lights and handles are grouped for convenience in Bowser synthetic dry cleaning unit (above). Monel cylinder is mounted in self-aligning pillow blocks and is driven by V-belt. Separate motors drive pump and ventilating fan. Frame is welded angle steel

Hydraulic motions are prominent throughout the Caterpillar tractor (below). Foot-pedal operated, independent hydraulic brakes are on each rear wheel of tractor, and lever-operated vacuum booster acts on both tractor brakes and the hydraulic brakes on rear wagon wheels. Hydraulic booster arrangement gives finger-tip steering, requiring effort of only one pound at rim of twenty-inch wheel. Powered by six-cylinder engine

Automatic curtain control, operated from an outside lever, exposes exact amount of negative sheet required in Rectigraph self-contained photographic unit (left). Control crank, electrically operated, winds the exposed print into a spiral tank, cuts it off, grips the lead edge and pulls it face up into the fixing tray. A brass gear with an internal spiral babbitted in the hub is on the rack bringing the print out

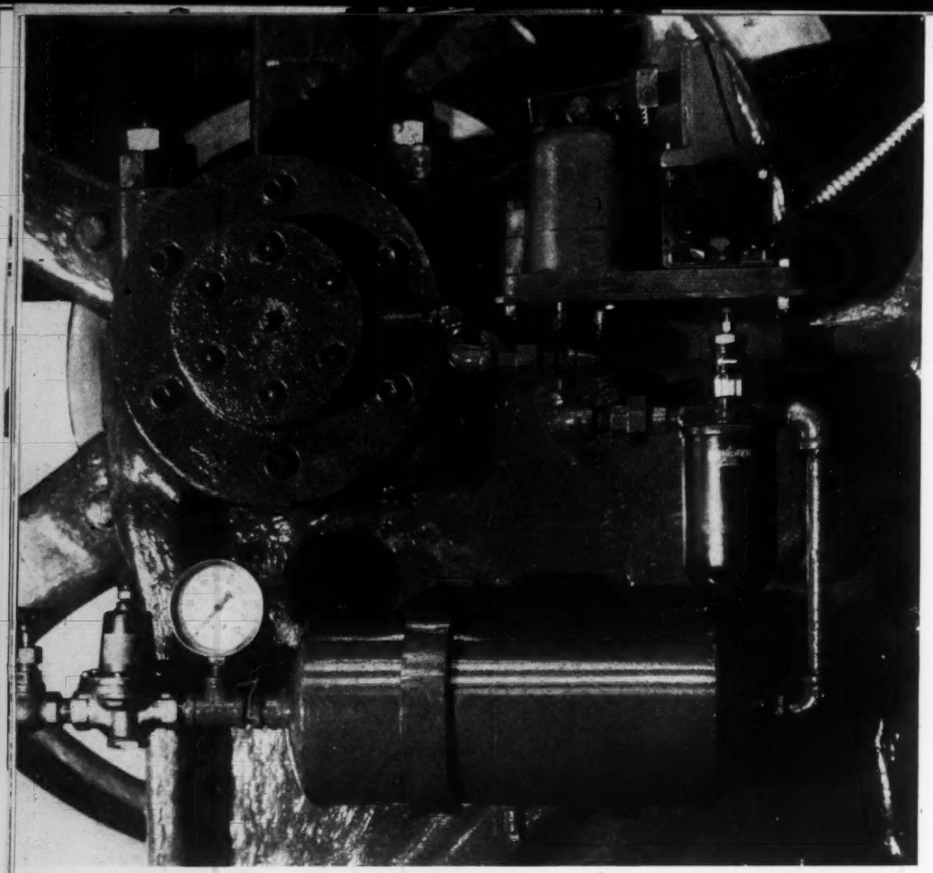

Fig. 1—Conventional pneumatic application for clutch operation includes regulator, surge tank, filter and solenoid-operated valve

By Kenneth D. Moslander

Air Is Economical Answer to Control Problems

DEVELOPMENT of pneumatic equipment such as air cylinders, pressure regulators, control valves, etc., has far outdistanced its application for drives and controls designed into machines. The majority of pneumatic machine applications are confined to relatively simple holding or displacement functions such as illustrated by air-operated chucks on machine tools and the use of a cylinder to actuate a friction brake or clutch of the type shown in *Fig.* 1.

Inherent potentialities of a compressible fluid such as air, however, provide the design engineer with certain opportunities in developing more complex sequence control circuits, operation cycle timing and machine counterbalancing possible by no other method at comparable cost and simplicity. The related subjects of sequence control and timing may well be considered together.

Most common of the several methods of obtaining sequence control or delayed timing is by use of a dashpot on the control valve. Such applications are common on crank or eccentric presses where a slight delay is desirable after the release of the ram clutch and before the brake is applied. Such dashpots may be of either the spring-opposed diaphragm or piston type utilizing a properly sized orifice to produce the necessary time delay.

Provides Precise Timing Medium

For more precise timing required where three or more elements must operate in a predetermined sequence, accurate control is obtainable by use of metering orifices. Shown in *Fig.* 2 is a diagrammatic sketch of such a circuit wherein three air cylinders may be operated in any predetermined sequence, each operating a given time interval after the other.

Air is supplied through a moisture trap and pressure regulator to a surge tank. This tank serves to eliminate compressor pulsations from the pneumatic system. Two lines are taken from the

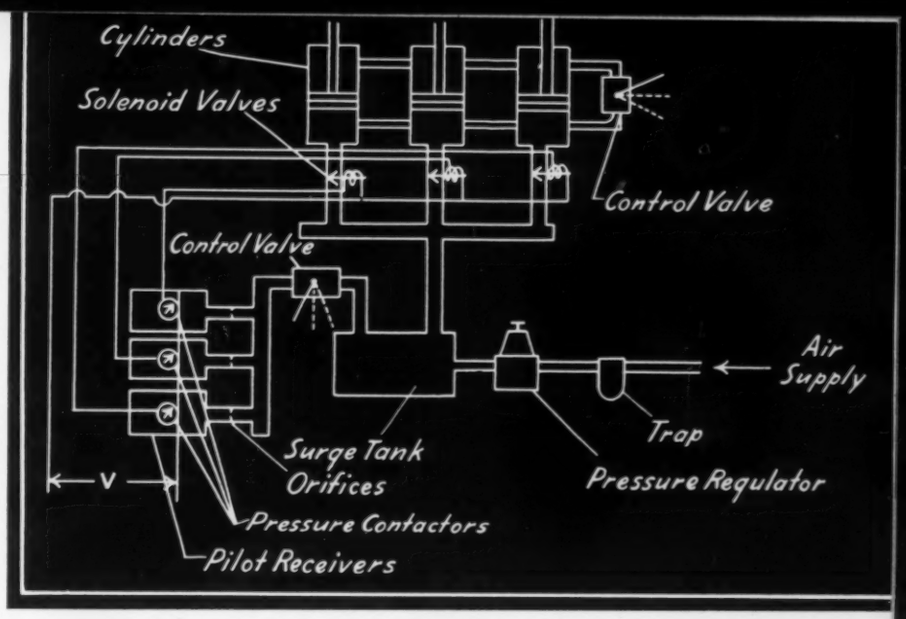

Fig. 2—Pneumatic variable timing and sequence control circuit for three elements may be extended easily for any number

tank. One of these supplies the cylinder circuit, the other the pilot timing circuit shown in the lower left. The pilot circuit consists of three receivers connected to the surge tank through interposed orifices and a control valve. Connected to each receiver is a pressure-operated electric switch or relay.

In operation, when the control valve is opened to the pilot circuit, pressure builds up in the receivers until the contactors are actuated. The solenoid valves are thus opened, admitting air to the cylinders. Resetting is accomplished in this case by exhausting the receivers to atmosphere and shorting the ends of the cylinders, permitting external loading to return the pistons to their initial position.

In order to simplify the timing of such a circuit the pressure contactors should be set at pressures less than half of that maintained by the regulator in the surge tank. By so doing the rate of flow through the orifices will be constant and hence the pressure build up in the receivers will be at an approximately constant rate.

Sequence timing of such a circuit may be accomplished in two ways. First, if the pressure contactors are of an adjustable type, the pressure settings at which contact is made may be set so that these pressures are proportional to the desired time intervals between cylinder operations. Second, since the rate of pressure build-up in the receivers is substantially proportional to their volume, this volume may be varied by introduction into them of a fluid. Such a fluid should have a low vapor pressure at the operating temperature and should not readily accept air into solution at the operating pressures. Lubricating oil of medium viscosity is a generally satisfactory fluid although such liquids as glycerine, chlorinated diphenyls and ethylene glycol may be used.

Time Is Proportional to Volume

In the event that this second method of timing is used, shielded sight level gages may be installed on the receivers and calibrated in units of time (which, as was stated before, is practically proportional to volume).

It is evident that the details of the application of such a timing circuit will vary with the specific problem. For example, if rapidly repeated sequences are desired, the time necessary to exhaust the pilot receivers through the orifices would have to be reduced. This may be accomplished by installing a line between the receivers and the control valve, by-passing the orifices. A 4-way control valve would be necessary in this case rather than the 3-way valve indi-

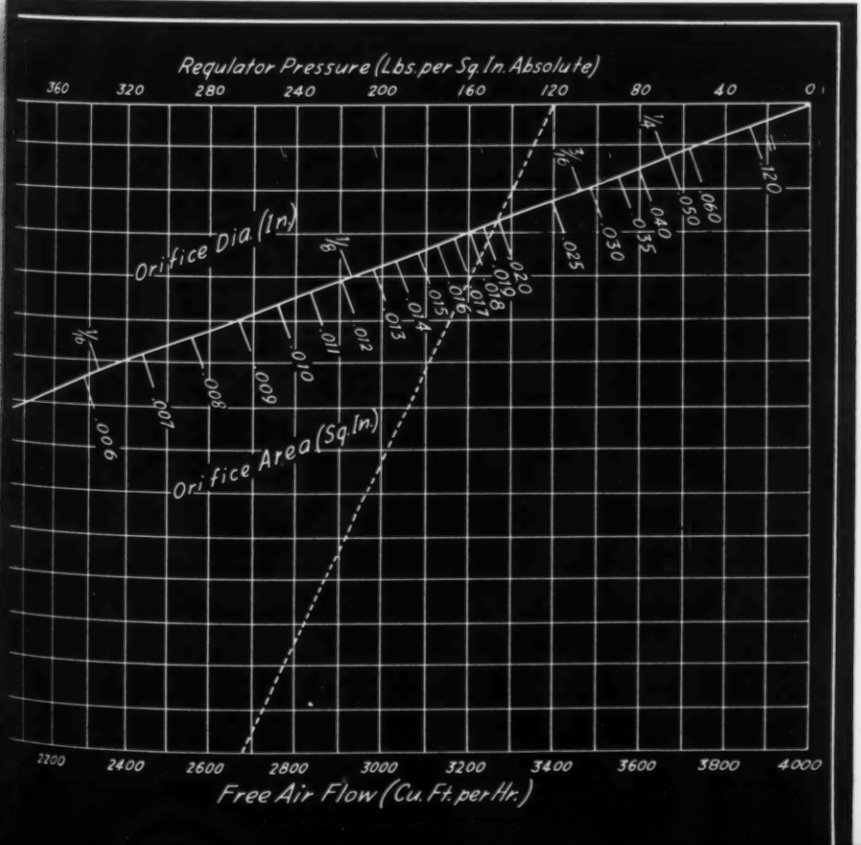

Fig. 3—Graph facilitates calculation of critical air flow through various orifices at 70 degrees Fahr. Orifice coefficient assumed unity

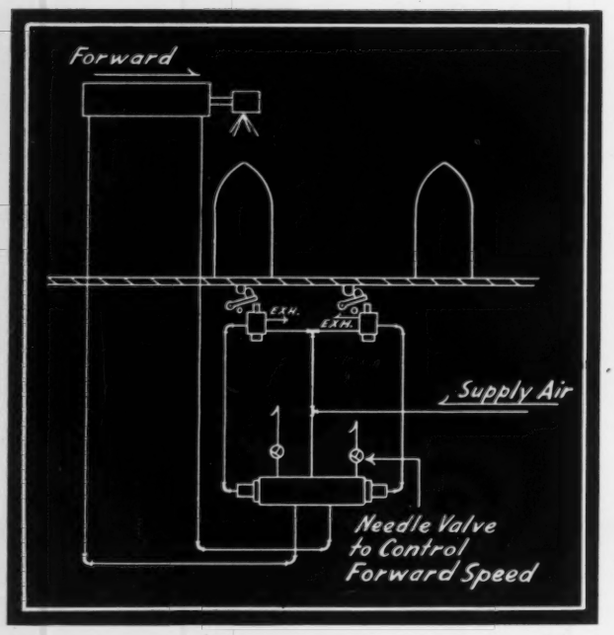

Fig. 4—Conveyor belt synchronized with pneumatic circuit provides continuous painting operation

cated in the schematic sketch shown in *Fig.* 2).

If it is desired to reset the rams positively, a similar valve change piped to the surge tank instead of the head end of the air cylinders would satisfy this condition. Exhausting of the head end air pressure would then be necessary to reset the system.

Flow through the orifices varies as the square root of the reciprocal of the absolute temperature. The range of operating temperatures normally experienced will introduce a timing error from this source of far less than that caused by the regulator and the cylinder friction losses.

Calculation of the rate of flow through the orifices will be simplified by the nomograph, *Fig.* 3. In the preparation of this graph an orifice coefficient of unity was used. For sharp-edged orifices the flow rate obtained from this graph should be multiplied by a coefficient of approximately .65.

Illustrated in *Fig.* 4 is a pneumatic circuit which further exemplifies the degree of precision control obtainable. Objects which are to be painted by a spray gun are spaced at equal intervals on a continuous conveyor belt. Metered air passes through a control valve and actuates a cylinder which traverses the spray gun at the same speed as the conveyor. Lugs fastened to the under side of the belt trip pilot air valves to control the main valve as well as the air pressure to the spray gun. With this circuit, paint is applied for a fixed interval of time to each piece as it moves continuously.

The press in *Fig.* 5 illustrates the extent to which air is being used in metal-forming equipment. In order to compensate for the weight of the ram so that the load on the work may be controlled accurately some form of counterbalancing is desirable. Air cylinders, shown mounted on the top of the press, afford a simple and efficient solution.

If the drawing dies used in conjunction with these presses require a deeper draw on one side than on the other, provision must be made in the press bed to cushion the greater thrust of the side with the deeper draw. Two methods are available to accomplish this cushioning. One is by means of springs and the other by use of air cylinders. Since the cushioning of the bed may result in a travel of several inches, use of springs has the disadvantage of an increasing load in direct proportion to the bed travel. Air cylinders installed or constructed integrally with the bed may be easily controlled to produce but slight increase in load during the bed travel.

For maximum speed and flexibility of control, air is also used for clutch and brake operation. In ap-

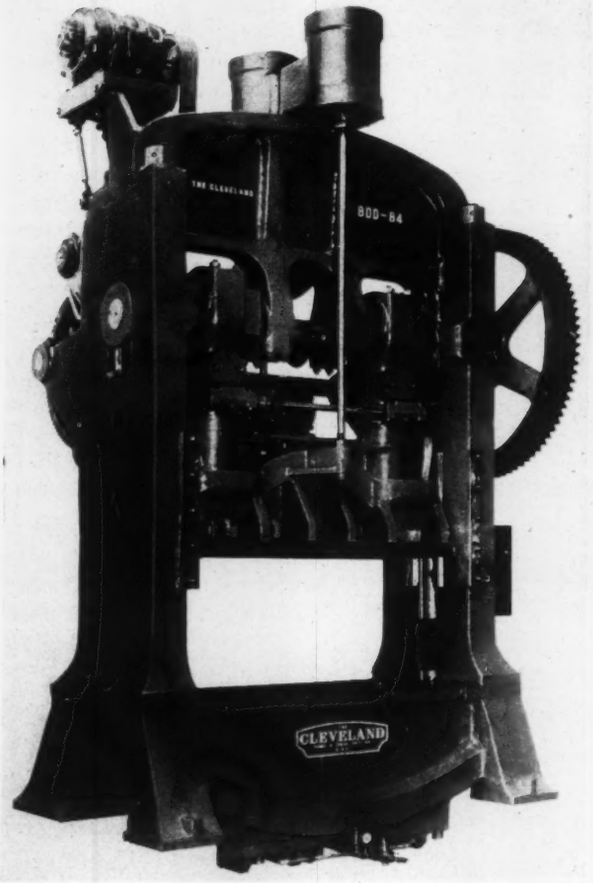

Fig. 5—Press incorporates pneumatic control to operate clutch, provide ram counterbalancing bed cushioning

plications of this sort air affords a most satisfactory medium of operation not only because of its speed of response to control but also because it may be exhaust directly to atmosphere.

MACHINE DESIGN gratefully acknowledges the assistance of the C. B. Hunt & Son, and the Cleveland Punch & Shear Works Co. in the preparation of this article.

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One of the benefits of Hele-Shaw Fluid Power (oil under pressure) that you are going to like is its smoothness. The oil under pressure from a Hele-Shaw pump is transmitted to the press, ram, or driven machine in a smooth, even flow. There's no vibration or thumping or jerking in the driven machine. The ram speeds up or slows down quickly. Even flow is responsible for greater accuracy in operation, longer life of the machine. Smoothness of Fluid Power is produced by a multiplicity of plungers in the pump itself. Investigate the smooth operation of Hele-Shaw Fluid Power and the many other advantages of Fluid Power by sending for our catalog.

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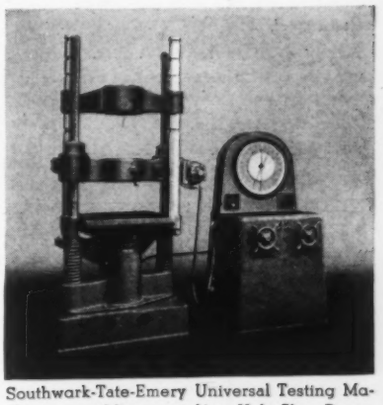
Cross sectional view of the Hele-Shaw Pump showing the multiplicity of plungers which are responsible for the smooth, even flow of Hele-Shaw Fluid Power.



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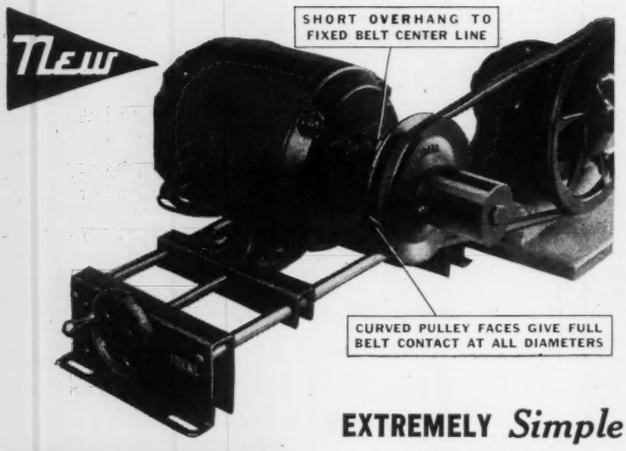

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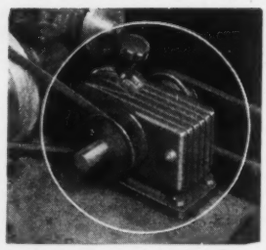

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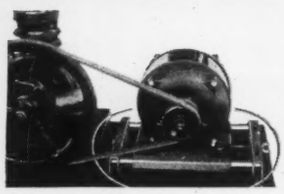

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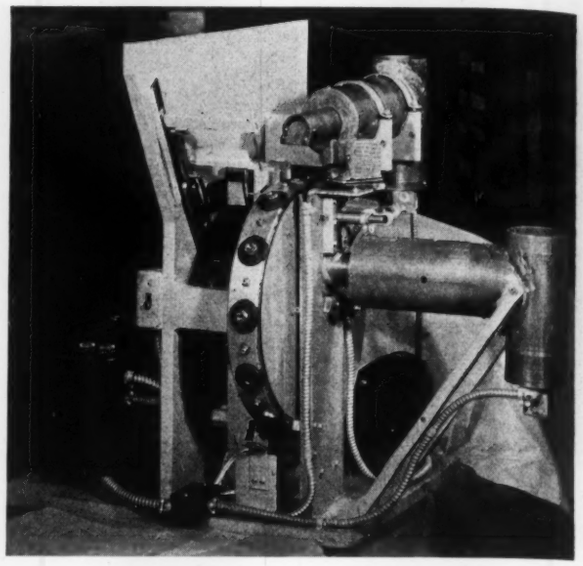


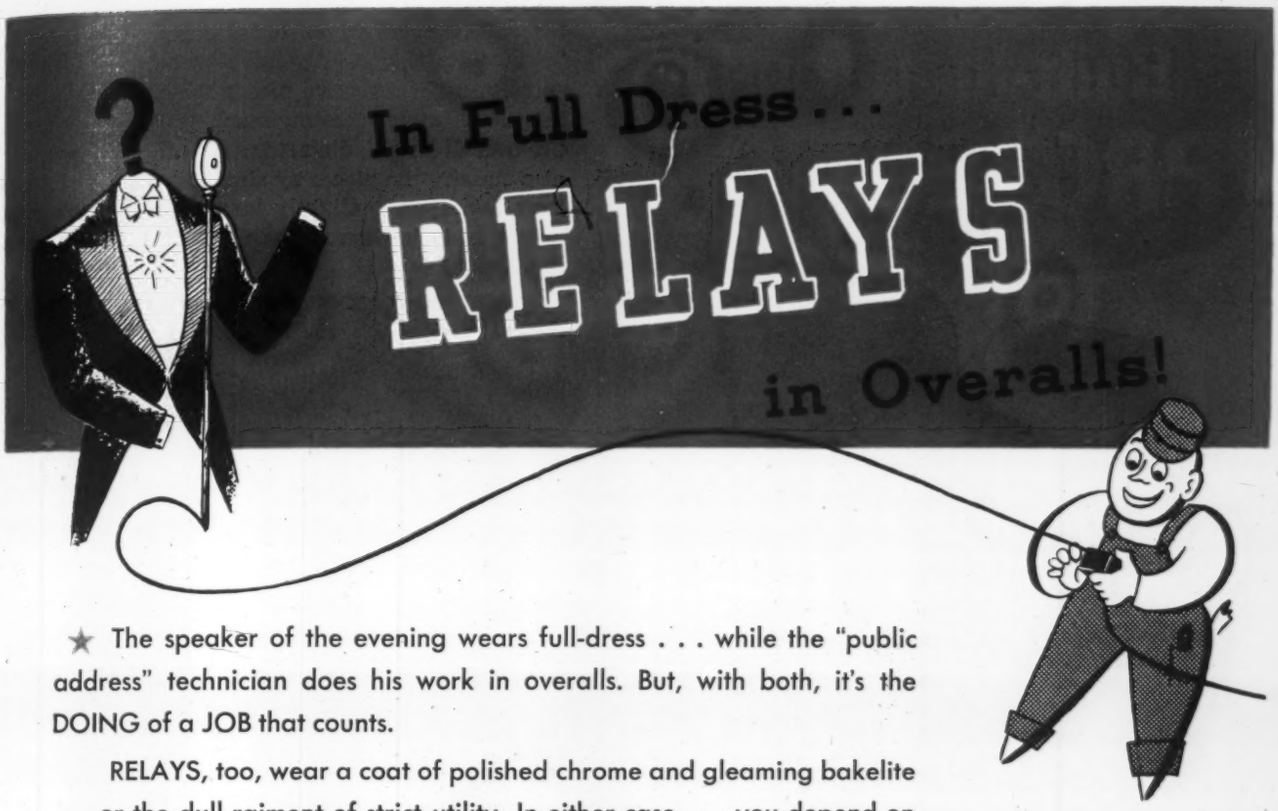
Fig. 1—Drilled lubricating holes in shackle bolts are tested automatically by use of electronic circuit

Electronic Controls Speed Production

DEVELOPMENTS in the application of electronic controls to machines make it desirable that the engineer be acquainted with these newly available solutions to his design problems. The reliability and long life of phototube controls, electronic relays and timers have been so well demonstrated as to deserve but passing mention. Examples of outstanding achievements in the ever-broadening field of machine applications of these controls, however, are presented in this article for the purpose of enabling the engineer to discover in his own design, analagous control problems capable of similar solution.

Completely automatic inspection machines in general use exemplify the manner in which these controls can be adapted to a number of operations. First there are tests for hardness. A ribbon of light only a few thousandths of an inch in thickness passes through the glass tube of a conventional gravity-operated scleroscope. The electronic control is so arranged that, upon the fall of the hammer, light beam interception does not cause actuation of the rejection mechanism. But, if the rebound of the hammer is not high enough, i.e., the piece is too soft, the beam is unintercepted and the piece is rejected by an energized solenoid.

In other instances the part is checked for concentricity and out-of-roundness. The piece is rotated while the surface being checked is in con-



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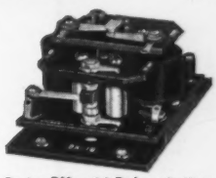

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tact with fingers which operate gaseous triodes or "electronic triggers" by infinitesimal contact pressures. Again defective pieces are ejected.

Other electronic testing machines similarly measure overall length, diameter and wall thickness, and also classify the pieces by size from limits of .0001-inch variation to slightly larger limits for overall height and diameter. Thus the parts may be automatically checked by machine for defects classified within predetermined dimensional limits.

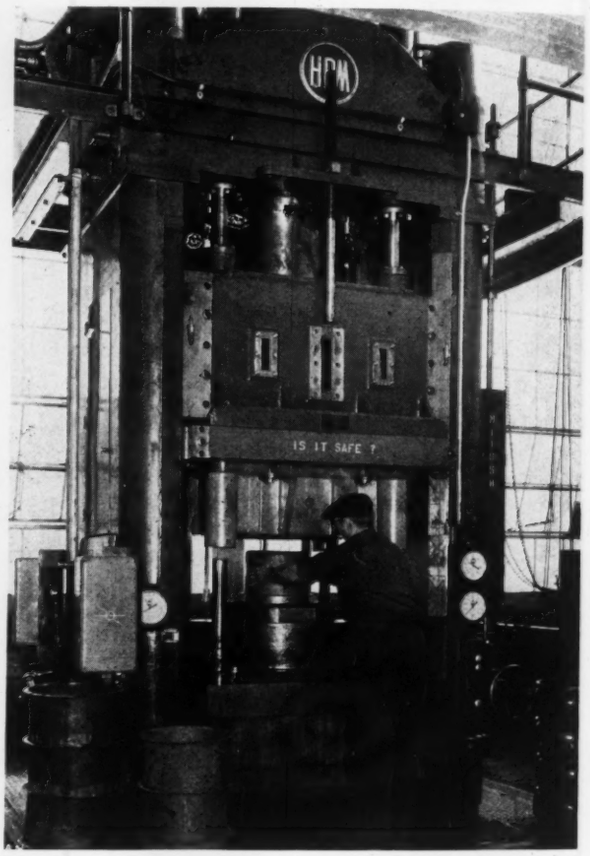
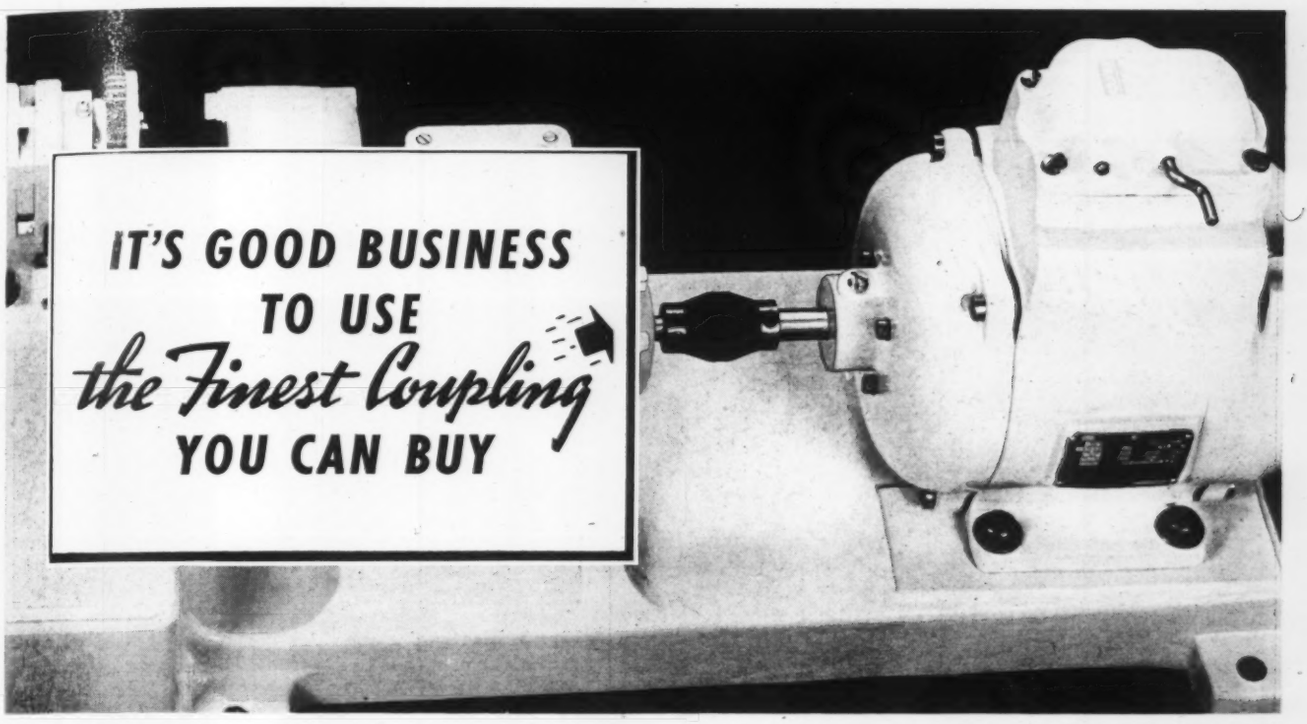


Fig 2.—Light curtain affords complete control of press operations in addition to insuring operator protection

Ease with which these "electronic gages" may be periodically checked provides another advantage of their use. Master gages, either perfect or incorporating one imperfection, may be run through the machine, and by noting their rejection or passage the proper functioning of the machine is ascertained.

Another interesting testing machine is in *Fig.* 1. Spring shackle bolts used in automobiles have a hole drilled down their center which meets another hole coming in from the side for lubrication of the complete shackle assembly. As these holes are comparatively small and are drilled at high speed, breakage of drills or plugging by chips or shavings is not uncommon. However, adequate lubrication of the assembly requires that these holes be clear.

Testing is accomplished in the machine illustrated. Bolts are inserted manually in receiving holes in a rotating drum. A geneva stop mechan-



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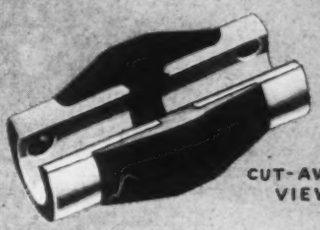

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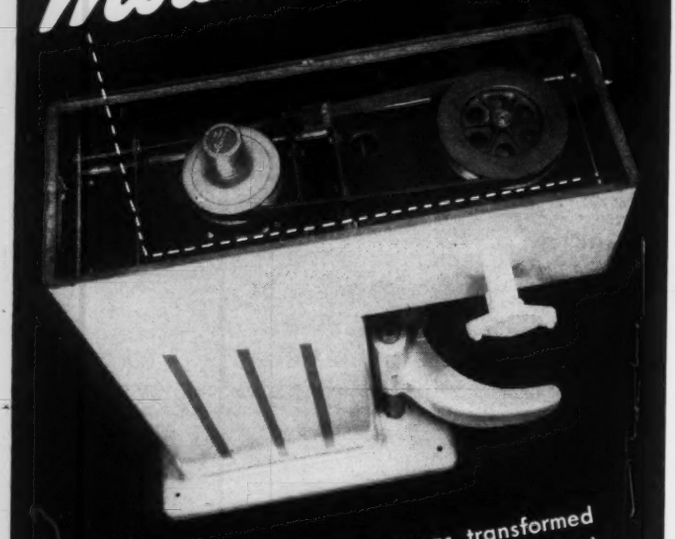

This fixed-speed dough mixer was transformed into a flexible, smooth-performing, highly-efficient machine. Now, any speed is available and speeds are changed quickly while mixing continues.

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ism moves them to the vertical position at which phototube inspection occurs. Defective bolts are dropped out at one position of the drum, satisfactory ones at another.

Representing a distinct advance over the original methods of mere press operator protection by means of a single light beam, the application in *Fig.* 2 not only provides complete light curtain pro-

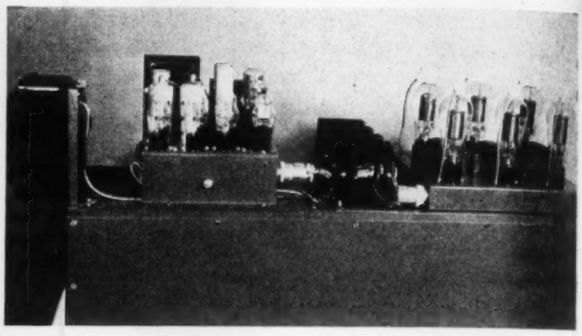

Fig. 3 Electronics provides complete control of work holder and tool in automatic broaching machine

tection on all sides of the press but at the same time affords complete control of operation without the use of pushbuttons or foot switches.

The light curtain projector is in the housing on the left front side of the press. The light beam is projected across the front of the machine to a mirror which reflects it across the end to another mirror which directs it across to the phototube.

In operation, a blank is placed over the die; the operator steps clear; press operation occurs; the finished piece is removed and the cycle repeated, all controls being actuated by operator interception of the light curtain.

In this type of control, safety features are built in which will stop the press in the event of inter-electrode shorts within the phototubes or amplifying tubes as well as because of power failure, open resistors or open grid leaks.

Are Ideal for Severe Service

Automatic or semiautomatic machines incorporating frequent operation of electric pilot or control circuits find extensive applications of electronic relays. In such machines, in less than the normal maintenance period, hundreds of thousands of cycles of operations take place. Under such service conditions contacts may break down as a result of mechanical wear, relay springs may fatigue and general mechanical breakdown of the pilot circuit may be experienced. Severe service of this kind justifies the added expense of electronic relays which have "no moving parts."

A typical example of such an application is a broaching machine control circuit. This circuit incorporates, in addition to complete phototube light curtain operator protection, control of the complete operations of the work clamp and broach.

The anode or plate circuit of the electronic tubes

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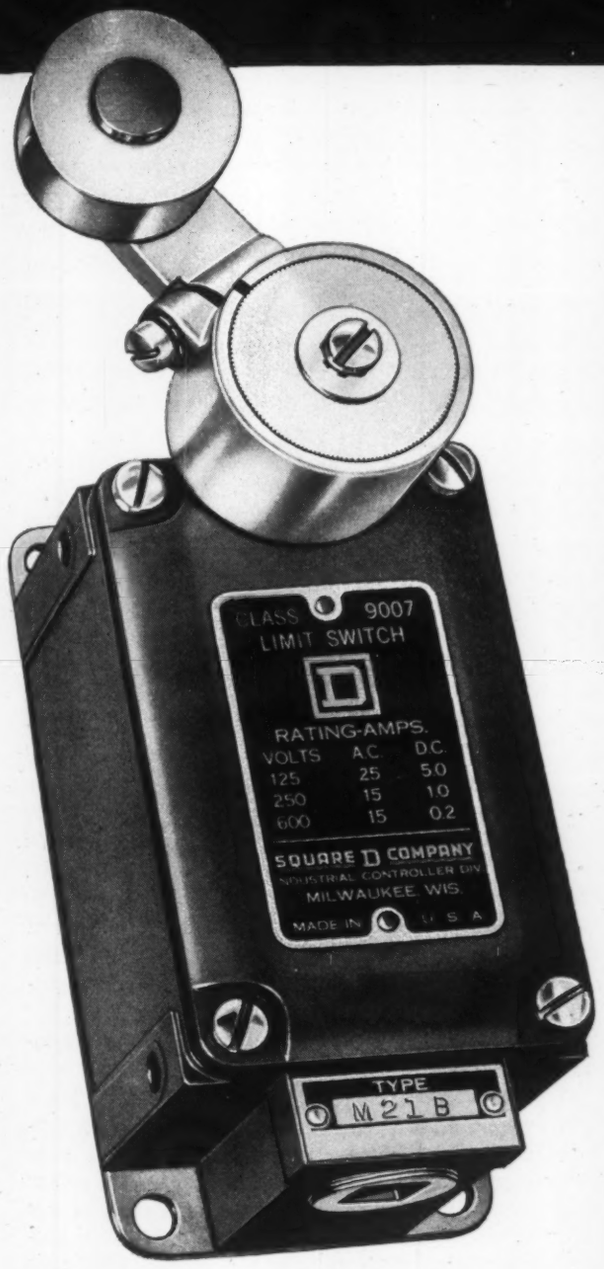
a New MACHINE TOOL LIMIT SWITCH



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Type M limit switches are designed to withstand extremely severe machine tool service.

Only 8° travel is required to trip the snap-action mechanism. Operating levers can be supplied to furnish as much as 45° emergency overtravel in either direction.

Operating levers can be adjusted to any position around a complete circle.

Neoprene gaskets with the die-cast enclosure provide an oil-tight and dust-tight construction.

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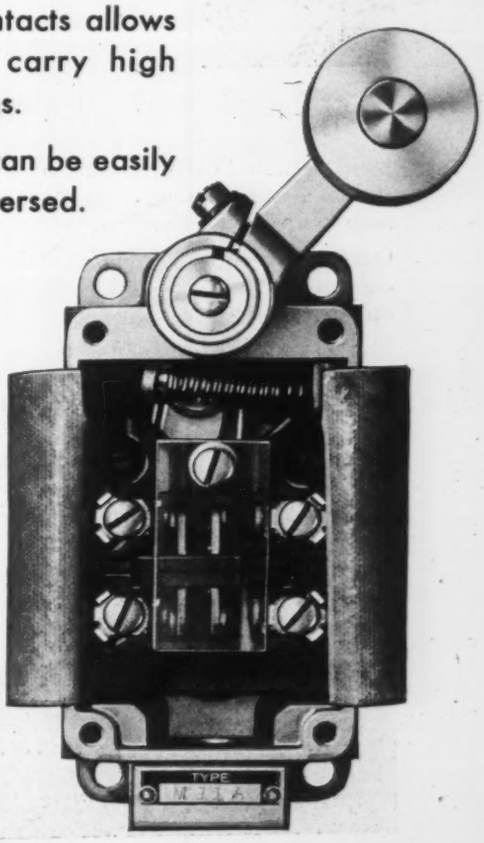
Heavy spring pressure on double break, double throw silver contacts allows the switch to carry high electrical ratings.

Return springs can be easily removed or reversed.



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This "pellet" switch, developed originally for trunk and glove compartment lights on cars, has now been improved so that it can be used for sliding panel lights, door post switches, stop lights, under the hood lights, and many other uses.

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Mercury contacts never stick, and reliable operation prevents needless battery drain. Because of its sturdy construction, it can make millions of clean make-and-break contacts, yet road shock and engine vibration can never deteriorate it. It has a rust-proof exterior, no wires that can break off, and is practically impervious to moisture. This new G-E KON-NEC-TOR is literally good for the life of a car.

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operates the solenoid valves of the hydraulic circuit directly. There are no mechanical motions in the control circuit between the start of the sequence by the interception of the light beam until the sequence has been completed to the actuation of the valves.

Where precise timing control is necessary such as in plastic molding presses and the like, electronic timers are finding broad application. These timers, which are adjustable for delay periods up to several minutes, are used to control machine loading time, time of application of pressure to the plastic in the mold, and curing time, after which the circuit recycles.

The easily adjustable feature of these timers is important in plastic press work since the time for the various molding operations varies with the plastic mix, the size and shape of the molding, and its complexity.

Provide Instantaneous Reset

Electronic timers incorporate the advantages of instantaneous reset. As a result of the use of a gas tube similar to the thyratron in the output stage, after the condenser in the grid circuit has become sufficiently positive the tube "fires" and in so doing passes its maximum current at applied voltage until the circuit is released. Consequently, the time delay is not effected by variations in line voltage or temperature. Timing accuracy which is within 1 per cent, plus the absence of all moving parts, makes such instruments ideally adaptable to the timing of repetitive machine operations requiring high precision control.

Control of penetration in welding steel sheet or plate has always, before the phototube application, demanded skilled manual control. In the electronic control, a phototube responds to the "color" of the underside of the weld. If the spot brightens, indicating the application of excess heat, the speed of traverse is increased or, in the case of automatic oxyacetylene welding, the blowpipe is raised slightly above the work. If complete penetration is not being obtained, the spot darkens and the phototube effects control in the opposite direction.

Applications of phototubes for differentiating between changes in light intensity have been subject to a number of improvements which have greatly increased precision. For example, in smoke detectors, variation of line voltage as well as age affected the light source intensity. This was particularly undesirable in some chemical processes where control was based on the translucence of a solution.

These two disadvantages have been compensated for so that the sensitivity of the system remains constantly at the level set at the time of installation.

MACHINE DESIGN gratefully acknowledges the contributions of the following companies to this article: Electronic Control Corp., Photoswitch Inc., R. W. Cramer Co., United Cinephone Corp., and Westinghouse Electric & Mfg. Co.

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RIGHT: *Marine Reverse and Reduction Gear*
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BELOW: *Machine Tool Clutch*
BELOW, LEFT: *Model E Heavy Duty Clutch*

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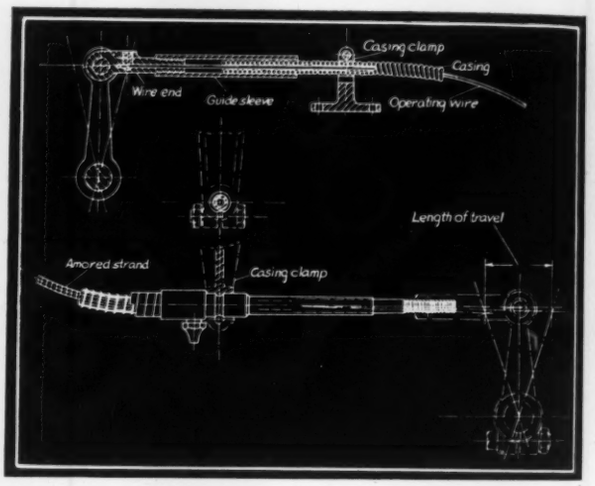
Ingenuity Simplifies Design

(*Continued from Page 37-S*)

cation of the wire, producing a smooth nonsticking action.

This device has operated successfully for several years, and as a result it was decided to use a similar construction where greater forces are transmitted for several feet between a camshaft and an oscillating member which is also adjustable in position. In this case a "push-pull" control, intended for use as a flexible control link, is em-



ployed for the frequent intermittent operation required. The illustration indicates the construction of this device, which may be used for loads as high as 200 pounds in tension or short stroke compression. When longer strokes are required in compression the load must be reduced because of the unsupported length of core in each end fitting. This second mechanism has now operated continuously for three years with no trouble at 10 to 25 three-inch strokes per minute.

It is perhaps unnecessary to point out that the installation of any such type of casing-guided link should require as few bends as possible with radii as large as possible to reduce friction and backlash.

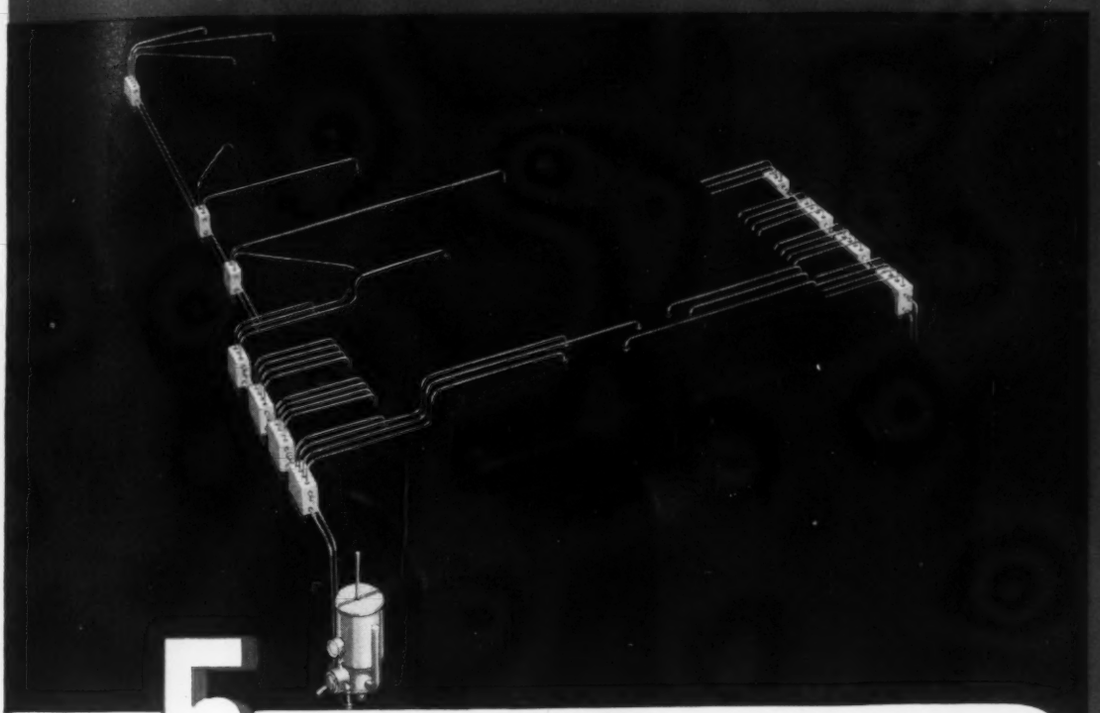
Air Draft Improves Clutch

By F. W. Gaines
The Ajax Mfg. Co.

DOUBLE-DRAFT air ventilation for cooling clutch friction disks in the forging machine illustrated greatly increases the life and efficiency of the driving unit. Air in great volume is pulled in by scoops at the hub on both sides of

(*Continued from Page 68-S*)

How to Increase Your Customers' *Profits..*



5 ways with Farval Systems

For as little as 5% you can—
Install Farval Centralized Systems—insure positive lubrication of all bearings—and pay for the added investment by creating these 5 big savings:

1. **Reduced power consumption — by as much as 30%**
2. **Increased life of bearings—up to 10 times**
3. **Reduced labor of oiling—90% or more**
4. **Lowered maintenance cost — as high as 75%**
5. **Increased production — by eliminating shutdowns due to lack of lubrication.**

The Farval System is a positive, mechanical method of delivering lubricant under high pressure, to a group of bearings from one Central Station, in exact measured quantities and as frequently as desired.

The Farval Valve is simplicity itself—it has but 2 moving parts, contains no springs nor check valves, is adjustable and indicating. May we send a Representative?

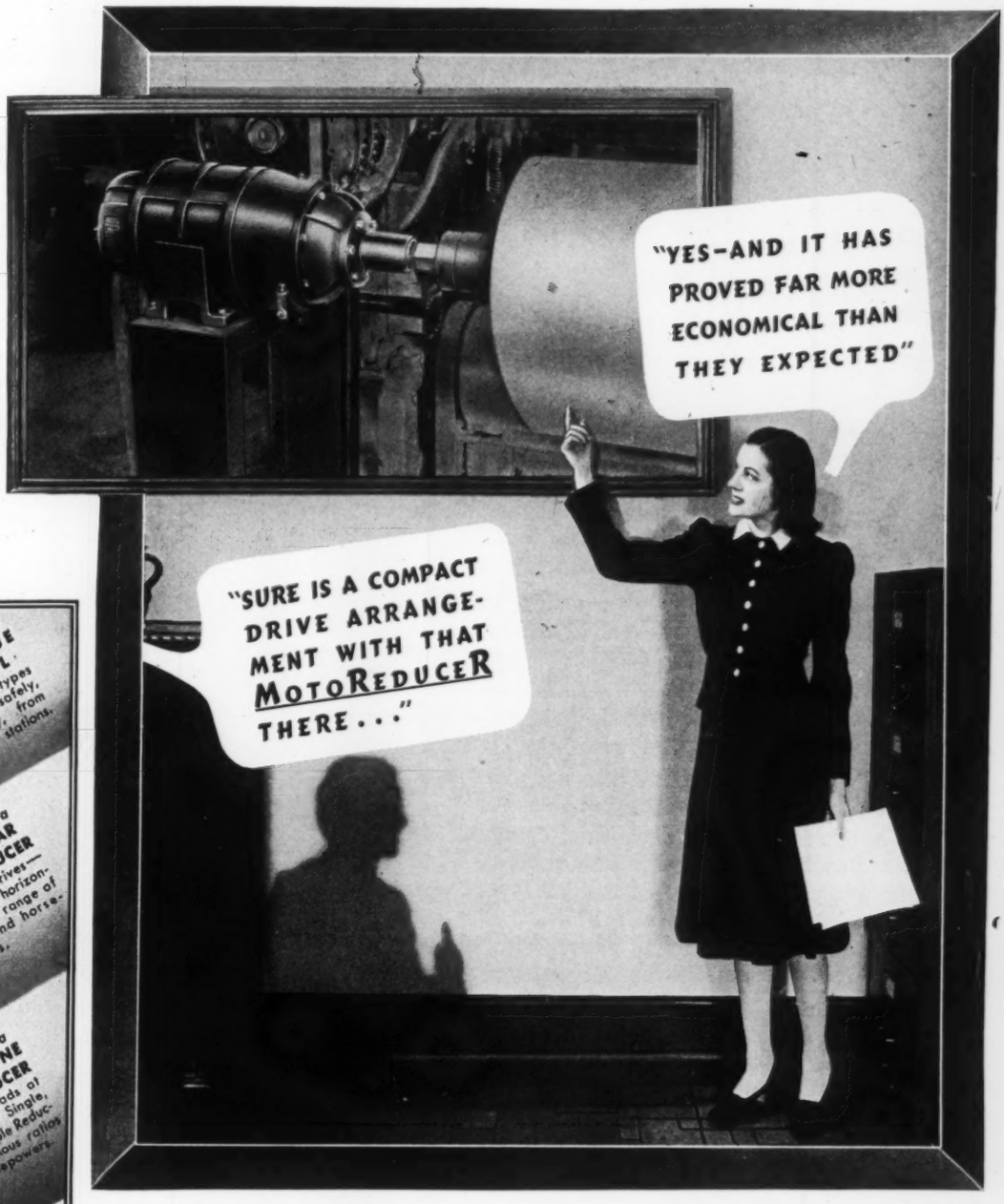
The Farval Corporation, 3265 East 80th Street, Cleveland, Ohio.

Affiliate: The Cleveland Worm & Gear Company, Manufacturers of Automotive and Industrial Worm Gearing
In Canada: PEACOCK BROTHERS LIMITED

FARVAL

CENTRALIZED SYSTEMS OF LUBRICATION

Hanna
Cylinders
for
POWER
Movement
IN ANY DIRECTION
YOU'LL
WANT
THIS
New Complete Catalog
TO CHOOSE THE
RIGHT CYLINDER QUICKLY
HERE it is—the new Hanna Cylinder Catalog No. 230—just off the press—packed full of illustrations, dimensions, capacities and valuable engineering data to help you select the proper cylinder for every application. In addition to covering the broad line of standard Hanna Cylinders, this new catalog covers cushioned cylinders, operating valves, speed control valves, and accessories.
Catalog 230 is available to executives and engineers requesting it on company letterheads. No obligation, of course. Write today.
HANNA ENGINEERING WORKS
1772 ELSTON AVENUE • CHICAGO, ILLINOIS
Air and Hydraulic RIVETERS
Air and Hydraulic CYLINDERS
Air HOISTS


"YES—AND IT HAS PROVED FAR MORE ECONOMICAL THAN THEY EXPECTED"
"SURE IS A COMPACT DRIVE ARRANGEMENT WITH THAT MOTOREDUCER THERE . . ."

Philadelphia LIMITORQUE CONTROL operates all types of valves, etc., safely, economically, from convenient stations.
Philadelphia WORM GEAR SPEED REDUCER right angle drives—vertical or horizontal. Wide range of ratios and horsepowers.
Philadelphia HERRINGBONE SPEED REDUCER for heavy loads at high speed. Single, Double, Triple Reductions, various ratios and horsepowers.
Philadelphia MOTOREDUCER The economical self-contained drive. Horizontal or Vertical types—various ratios and horsepowers.
Philadelphia GEARS All types and sizes of industrial gears. Can be supplied in all materials.

• Just read the reasons why you get super-economy in these direct-connected drives for machines or line shafts:

The Philadelphia MotoReduceR is versatile in application to any type of equipment—under practically any condition—always giving high efficiencies.

Being simple in design and construction, with all parts readily accessible, also having ample and automatic lubrication, the maintenance cost is negligible.

The MotoReduceR is available in a wide range of ratios and horsepowers . . . . Consider its application to your requirements. Our latest descriptive literature will point out its economy—write us.

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Industrial Gears and Speed Reducers
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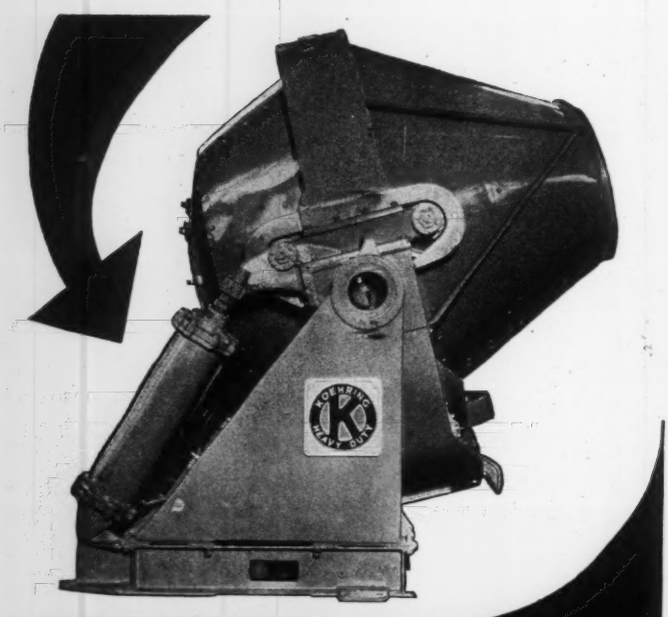
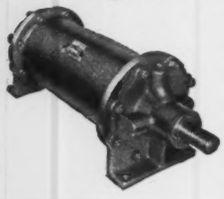


NOPAK Air Cylinders Help Set *World's Record*

A new world's record for pouring concrete was established on the giant Coulee Dam project. A vital factor in this performance was the battery of eight 4-cubic yard Koehring Concrete Mixers. Revolving and tilting continuously for 24 hours, without stop, they produced an average of 861 cubic yards of concrete per hour.



NOPAK Air Cylinders, both Standard and Heavy Duty, are available in Non-Cushioned, Self-Regulating Cushion and Adjustable Cushion Types—in 6 standard mountings.

A pair of NOPAK Heavy Duty Air Cylinders on each mixer (controlled by NOPAK 3 and 4 way operating valves) tilted and dumped the heavy mixer drums, loaded to capacity, from 24 to 27 times an hour. Could you ask for a more severe test of cylinder durability and power, plus smooth unfailing performance?

The flat-disc principle, basic patented feature of all NOPAK operating Valves, makes them practically leakproof and wearproof, provides perfect control of air cylinder movements.

Isn't this the kind of valve and cylinder performance and control you want to build into your machines? Our engineers can help you to fit NOPAK Valves and Cylinders, for Air or Hydraulic Service, into your new designs for maximum efficiency and dependability. Write for details and descriptive literature.

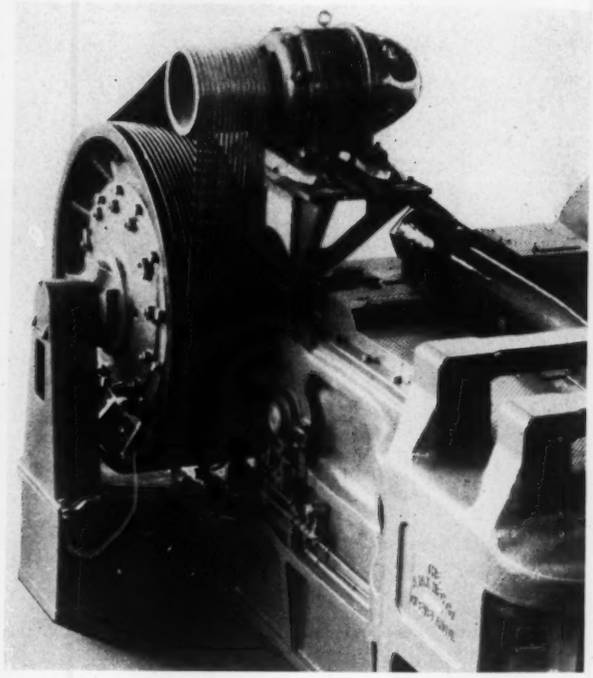
GALLAND-HENNING MFG. CO.
2752 S. 31st Street MILWAUKEE, WIS.

Representatives in Principal Cities

NOPAK VALVES and CYLINDERS
DESIGNED for AIR or HYDRAULIC SERVICE

(Continued from Page 62-S)

the flywheel, forced out centrifugally between the friction surfaces of the clutch plates, and discharged through openings in the outer clutch housing just inside the flywheel rim. This double-draft provides a generous circulation of air and ample cooling throughout the clutch, prevents excessive heating at highest frequency of engagements, and improves the operation of the friction



surfaces. The entire flywheel assembly is mounted on widely spaced antifriction bearings, so that there are no overhanging torque loads.

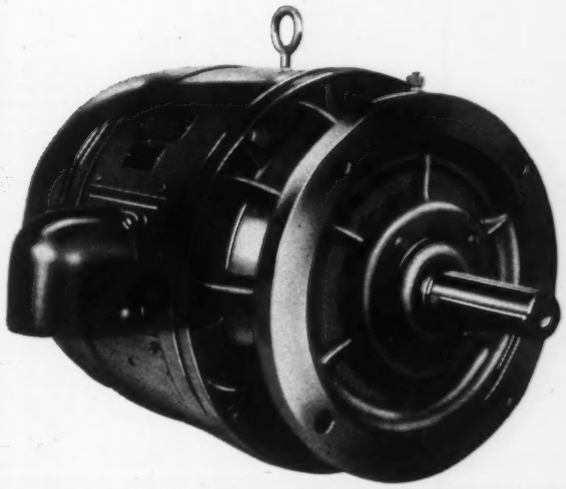
An important feature from the maintenance standpoint is convenient accessibility for lubricating both flywheel bearings and utilization of labyrinth grease seals and overflow discharge ducts to prevent lubricant from entering the clutch plates and reducing their friction coefficient.

Idler Effects Simple Clutch

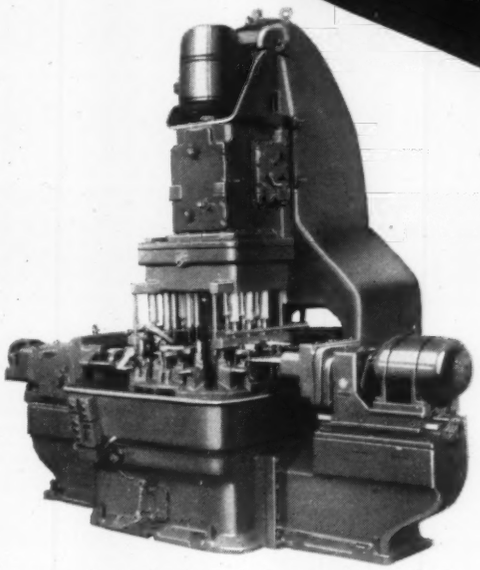
By J. I. Blair
Chief Engineer
Worthington Mower Co.

FINGER-TIP control for adjusting power-driven units on a mower is supplied from the hydraulic pump shown in the illustration. Cleverly and conveniently tucked away between the radiator and radiator grille, the pump, which is a popular and dependable high pressure plunger type unit, is readily accessible by removing the lower panel of the grille. The oil reservoir is mounted above the pump inlet for gravity feed

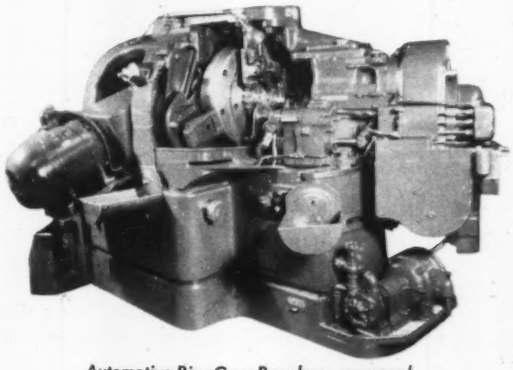
CHECK THESE CONSTRUCTION FEATURES



They Make DELCO MOTORS Better Power Plants for Industrial Applications



4-Way, 18-Spindle, Hydraulic-Feed Machine with 4-station indexing table for drilling, boring, reaming, chamfering and tapping spring horns for automotive assembly. Driven by four dynamically balanced Delco motors . . . three constant-speed, and the other reversing-type.



Automotive Ring Gear Rougher—powered by Delco motor, dynamically balanced.

1 Delco motors are *dynamically balanced;* reduced vibration results in longer life for motors and machines . . . quieter operation.

2 Generous use of materials in frame, feet and radiating ribs provides exceptional ruggedness and cooler operation.

3 All alignments are established in first machining operation, and maintained throughout production by grouping operations wherever possible.

4 Stators are wound, dipped and baked while separate from frame, to permit better workmanship and easier removal for service. Slot laminations are exceptionally smooth, to extend life of insulation.

5 Coils are not only well insulated, but *individually taped* for additional protection; taping extends well into slot laminations.

6 Contact surfaces between stator and frame, and between end laminations and fans, are machined for better contact, better heat dissipation.

7 Use of master gauges assures that rotor hole and key-way are in same plane, to eliminate rotor wobble.

8 Inner race of ball bearing is locked on shaft to prevent "drifting" and freezing of bearing.

9 Special emphasis is given to accurate machining of shaft and bearing surfaces for longer life, easier replacement.

10 Highest quality baked enamel finish—will not chip or crack under hardest usage. Delco motors maintain good appearance.

Built to Satisfy Plant Engineers and Maintenance Men

The features that qualify Delco motors for industrial uses are the direct result of close cooperation between Delco Products engineers and the engineers and maintenance men in many large factories. Ideas and suggestions have been incorporated into Delco motors through the manufacturing experience and research facilities of General Motors Corporation.

Consult the Delco Products Engineering Department for recommendations to meet your requirements.

DELCO MOTORS

DIVISION OF GENERAL MOTORS CORPORATION

DELCO PRODUCTS DAYTON, OHIO

New VARIABLE VOLUME HYDRAULIC PUMPS

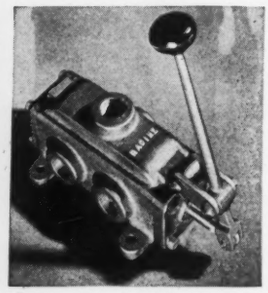
RACINE announces its new 1000# Variable Volume Pump. Advanced in design and construction, it incorporates the special advantages of smooth, quiet operation—needle roller bearings—mechanical seals. An exclusive method keeps vanes hydraulically balanced. Hydraulic governor automatically maintains desired pressure without by-passing of oil.

Capacities—12—20—30 gallons per minute
Variable Pressures—Up to 1000 lbs. per sq. in.
Mountings—Foot or flanged type

Let our engineers help you with your hydraulic problems; send for literature today.

RACINE HYDRAULIC VALVES

Engineers and designers you are offered a complete service for oil hydraulic systems—Variable Volume pumps—Feed controls—Pressure regulators. A complete line of hydraulic valves—Manual—Pilot—or Electrically operated. Let RACINE assist you with your hydraulic problems.



RACINE TOOL & MACHINE COMPANY
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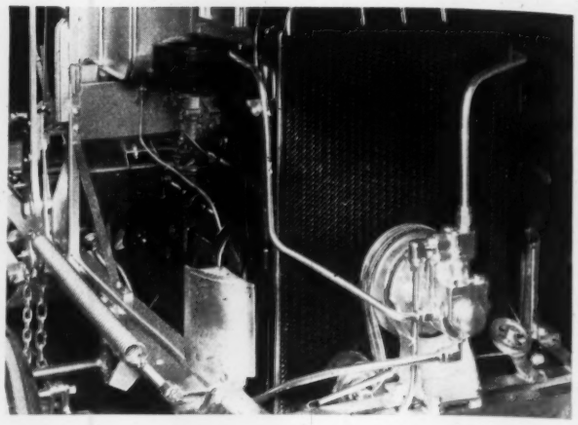
RACINE



and is concealed under the hood directly behind the radiator where the oil receives some beneficial cooling from the engine fan.

Pump drive is from the front end of the engine crankshaft and consists substantially of an extension shaft coupled by means of a spider and flexible disks to the engine fan pulley and supported in a self-aligning ball bearing flanged housing at the other end.

A deep-grooved V-belt drive pulley is used at the bottom. This, in conjunction with an idler pulley and a belt tightener cable, provides clutch means and belt take-up. The pump can therefore be allowed to remain idle when not in use, thereby prolonging the life of the belts and unit.

Balances Load on Drive

By Samuel Leven
Joy Manufacturing Co.

SYNCHRONIZATION of drives for a multiplicity of operating members is especially difficult to obtain through a single transmission in coal mining machinery. This is so because of the mining laws, restrictions in space, and a definite demand for extraordinary strength and weight to meet the severe conditions of mine service.

In the gathering head transmission of the Joy coal loader, two motors, mounted symmetrically on opposite sides of the longitudinal center line of the machine, drive similar gathering arm link motions in synchronized cycles and combine to drive the coal conveyor which travels lengthwise up the center of the loader. Because of the Bureau of Mines laws on exposed electrical units, the synchronization is accomplished mechanically, thereby increasing the complexity of the problem.

The most important design aspect of the transmission arises from the fact that each gathering arm requires a large amount of power during the working or loading cycle and then uses very little power during the idling or return part of the cycle. The problem of balancing the power load was solved by using a single shaft, the foot shaft, to drive the arms on both sides simultaneously. Then,

ARROW H&H SOLENOID MAGNETIC STARTERS

Across-the-Line Starters

★

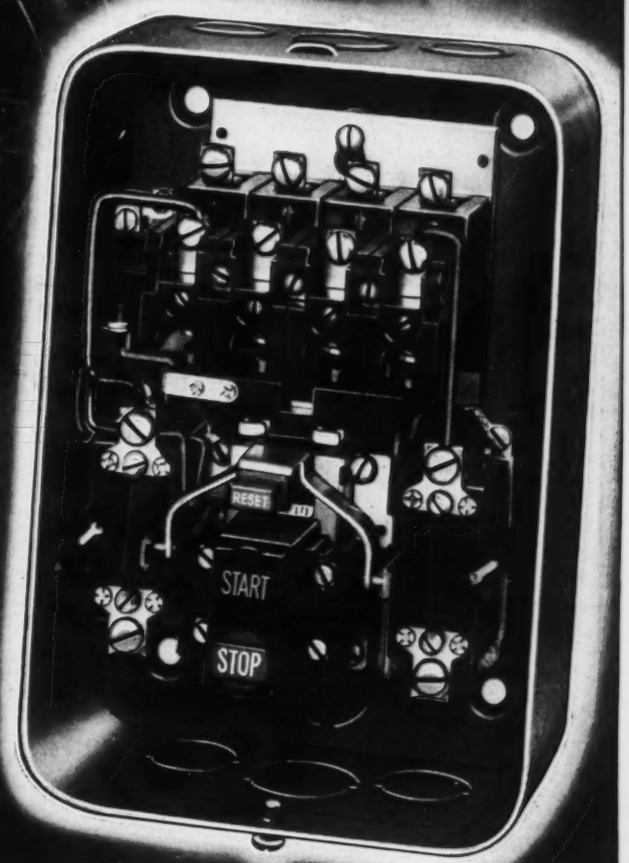
THERMAL OVERLOAD PROTECTION WITH INTERCHANGEABLE HEATERS.

UNDER-VOLTAGE PROTECTION OR RELEASE.

POSITIVE, QUICK MAKE-AND-BREAK SWITCHING MECHANISM; STRAIGHT-LINE LINKAGE.

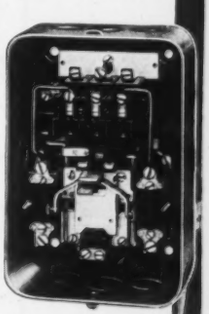
FOR CONTROL OF MOTORS OF 1 TO 7½ H.P., SINGLE OR POLYPHASE, A.C. 110 TO 550V.

Standard Finish, machine gray



IMPROVED DESIGN saves wiring-time and simplifies maintenance. Front-connected, with open view for inspection of contacts and connections. Heater coils are easily changed; ratings clearly visible. Switch unit removed or replaced by turning only ONE screw. Re-set button independent of cover.

Separate-unit construction for *each pole* of switch, —confining the arc, excluding dust. Switching mechanism in overload relays is insulated from the bimetal and heater. (The Starters are wired for *separate coil* circuit control, for voltages other than line, if so ordered).



Catalog 8-M will inform you fully of this line *and its companion line* of Solenoid Magnetic Contactors,—similar to the Starters but without overload protection or control buttons—figured at right. In writing for Catalog, remember that our *free Engineering Service* will plan arrangements of Arrow-H&H STANDARD UNITS to meet your *special* problems of motor control.

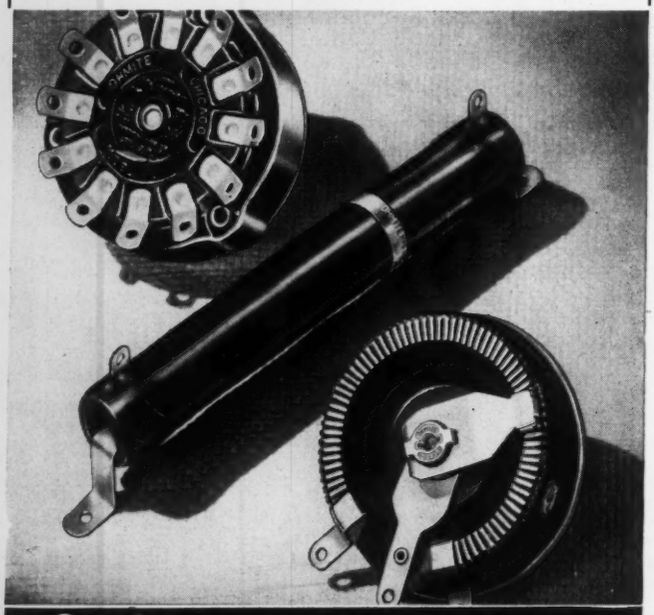
INDUSTRIAL CONTROL DIVISION

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.

Get quick service from world's largest stock of Rheostats, Resistors, Tap Switches

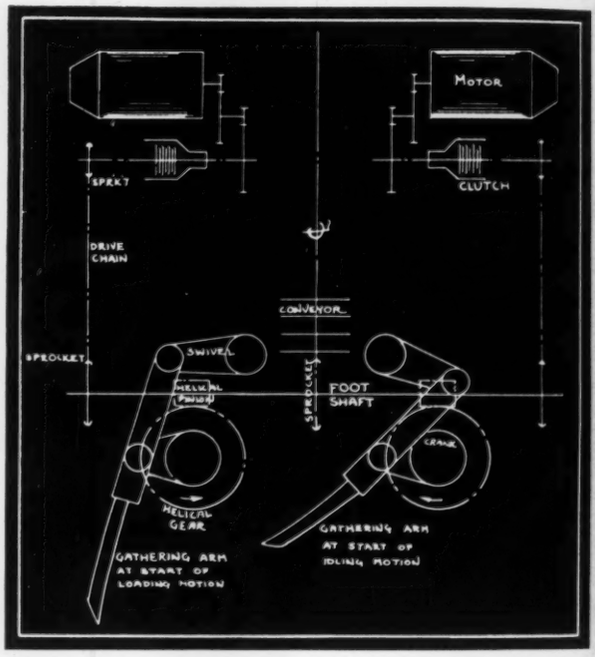
Here at one source is the largest, most complete stock of close-control rheostats, wire-wound resistors and high-current tap switches in the world. Hundreds of thousands of units in a wide range of types and sizes—available for immediate shipment. Thousands of cores more on hand, ready to be processed into the exact units you require—available with many types of terminals and mountings. Ohmite Engineers also will be glad to assist you in designing special units. ★ *Write for your copy of the 96-page Ohmite Industrial Catalog and Engineering Manual No. 40.*

OHMITE MANUFACTURING CO.
4830 Flournoy Street ★ Chicago, Illinois, U. S. A.



Be Right with **OHMITE**
RHEOSTATS • RESISTORS • TAP SWITCHES

by setting the original position of each helical gear with respect to each pinion the arms are so synchronized that when, for instance, the left-hand linkage is picking and loading coal, the right-hand side is going through the idling part of its



cycle. As a result, when one gathering arm linkage is idling, the torque from its motor is transmitted to the other side to help supply the power required by the linkage drive shaft during the loading stroke. Moreover, since the conveyor drive sprocket is located on the center of this same foot shaft, the power from both motors is applied simultaneously to the conveyor.

Product Sizes Require Speed Control

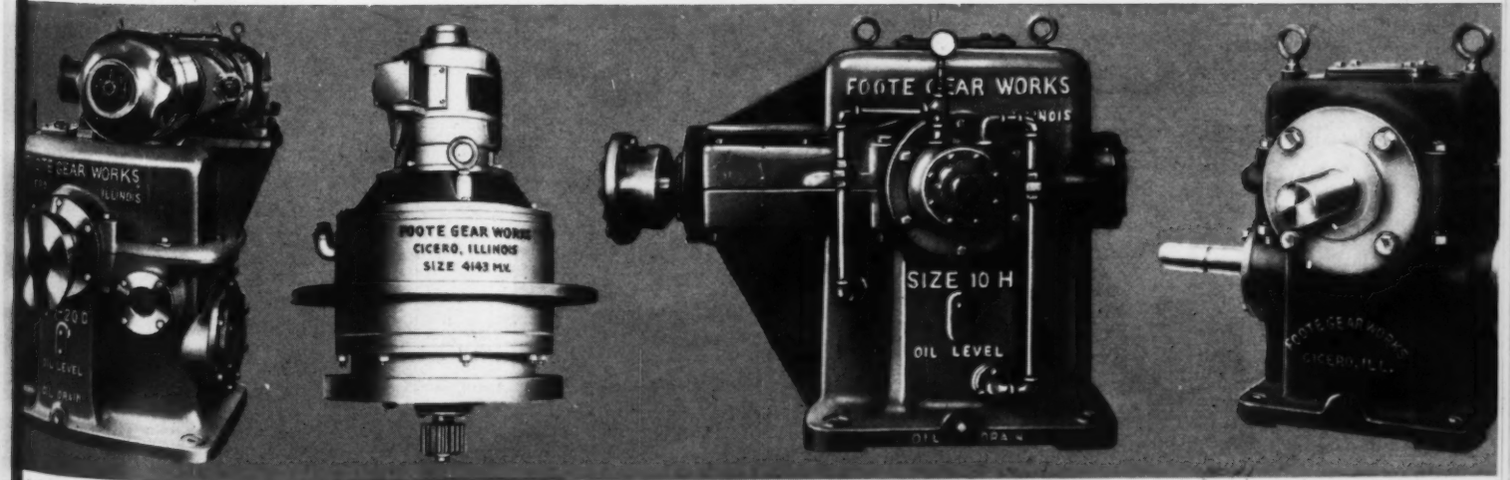
By R. C. Dickey
The International Paper Box Machine Co.

TO ACCOMMODATE a great many different sizes and styles of boxes, it is necessary to provide proper speeds for each size of box in a folding and gluing machine. Having a capacity of 80,000 units per hour, this type of machine utilizes the variable speed unit illustrated to control the carrier belt speed between 266 and 1000

Brad Foote

REDUCERS
CUT GEARS

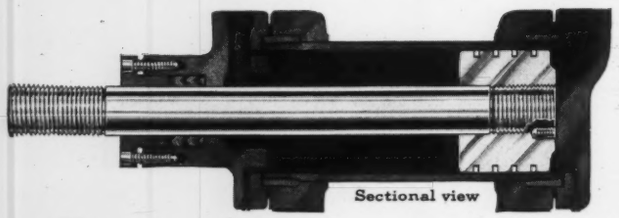
NGLE • DOUBLE • TRIPLE • RIGHT-ANGLE • HORIZONTAL • VERTICAL • MOTORIZED



ONE OF THE LARGEST GEAR CUTTING PLANTS IN THE MIDDLE-WEST

BRAD FOOTE GEAR WORKS

1301-G S. CICERO AVENUE • • • CICERO, ILLINOIS



Sectional view

Simple

Hydraulic Power Applications

The simplicity, ease of application, and flexible control of power movements are hydraulic power advantages made even more readily available by the design of Hannifin high pressure hydraulic cylinders.

Their patented construction is simpler, stronger, easier to apply to modern equipment. High efficiency hydraulic power and ability to withstand severe service are assured.

NO TIE RODS. This simpler design is stronger and removes a source of leakage. End caps may be removed without collapse of other parts of the assembly.

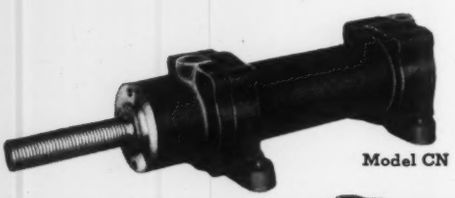
UNIVERSAL CAPS. End caps may be positioned independently, with inlet port at top, bottom, or either side. Caps can be moved without disturbing cylinder mounting or other parts.

AIR VENTS. Each end cap has air vents on three sides. This allows a vent at the top when inlet port is at either side or bottom.

LEAK-PROOF. Special mirror finish honing produces a cylinder bore straight, round, and perfectly smooth, assuring high efficiency piston seal with minimum fluid slip.

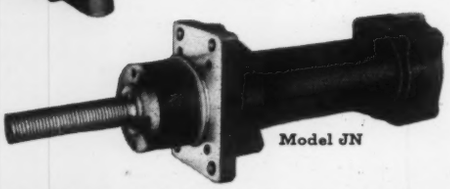
MANY TYPES AND SIZES. Available in seven standard mounting types, with small diameter piston rod, 2 to 1 differential piston rod, or double end piston rod, in a full range of sizes, for working pressures up to 1000 and 1500 lbs. sq. in. Special cylinders built to order.

Write for Bulletin 35-MD with complete data.



Model CN

Other mountings available



Model JN

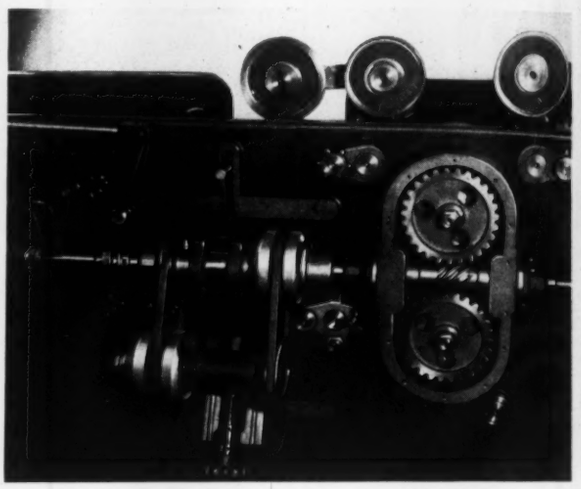
HANNIFIN MANUFACTURING COMPANY
621-631 South Kolmar Avenue • Chicago, Illinois

HANNIFIN
HYDRAULIC CYLINDERS

linear feet per minute. The speed changer unit is belted to a 7½-horsepower motor.

Power to various shafts in the machine is secured by an outboard drive shaft. From a worm gear on the outboard drive, hardened bronze gears are driven. All gears are enclosed and run in oil to reduce noise.

It is necessary that the feed belts travel at varying rates of speed, up to the maximum speed of the folder belts. And provision must also be



made to disconnect the drive from the feed so that the fold section of the machine may be running while the feed is stopped. The speed of the feed is regulated by speed changer V-sheaves. A simple clutch provides means for stopping the feed. The speed of the stacker is also controlled through speed changer V-sheaves.

Constant Tension Features Drive

By R. M. Scott
Chief Engineer
New England Butt Co.

IN A reeling operation it is necessary to slow down the reel as it fills up to keep the linear speed of the reel surface constant. It is also desirable to maintain a uniform or nearly constant tension on the material being reeled throughout the entire process. If this is accomplished a tight uniform package results without injuring the material.

On the reeling machine illustrated it is necessary to reel electric cables at varying speeds from 85 to 330 feet an hour. Reels varying in diameter from 42 inches outside diameter with 24 inches diameter of barrel, to a reel 66 inches diameter with 40 inches diameter of barrel are used. It is also desired to reel cable with various tensions depending on the size. This combination of specifications requires a total speed range of 14 to 1.

A torque gearmotor rated at one horsepower,

WESTINGHOUSE GEARMOTORS

ARE DESIGNED, BUILT AND TESTED AS *Complete* UNITS

Hundreds of installations in widely diversified industries have proved the outstanding advantages of Westinghouse Gearmotors for slow speed drives. Gearmotors save installation costs and reduce maintenance expense because no belts, pulleys or sprockets are required. The exact output speed can be obtained by simply installing one unit. And with a Westinghouse Gearmotor, low output speed is provided with the full efficiency of a high speed drive—efficiency ranging from 94% to 98%.

The design and construction of Westinghouse Gearmotors make it possible to solve many slow speed drive problems economically. Westinghouse Gearmotors are built as one complete unit. The result is a balanced drive in which all parts are matched to provide maximum results. Smooth, quiet operating gears are assured because Westinghouse makes its own gears—gears that are accurately cut from forged steel and heat-treated by the exclusive Westinghouse BPT process.

Built as one complete unit with all parts accurately balanced and matched, a Westinghouse Gearmotor will deliver its full torque under load and withstand the shocks of even the most severe service conditions.

Gearmotors are available in all standard motor ratings and in a wide variety of special enclosures. Your Westinghouse representative will be glad to give you complete details.

• • •

WESTINGHOUSE ELECTRIC & MFG. CO.
EAST PITTSBURGH, PA.

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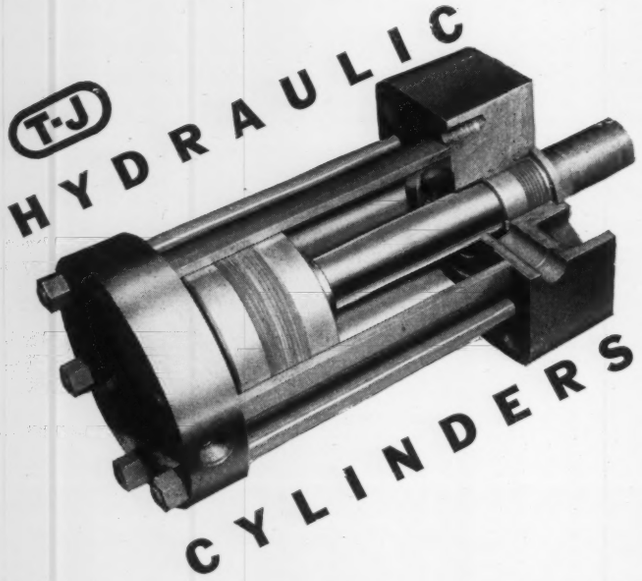
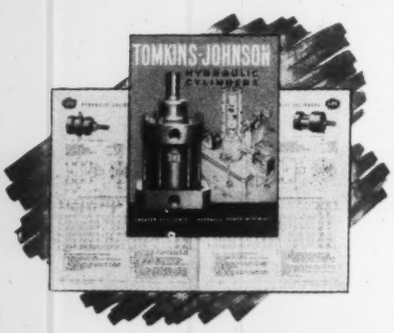
Westinghouse
GEARED DRIVES

TOMKINS-JOHNSON



Their "top form" performance construction features are given a thorough going over in our new catalog H-10.

Types of cushioning action are differentiated. Maximum allowable strokes per piston rod diameter are tabulated. Augmenting these and the cylinder specifications and dimensions are tables of pressures applied (for from 250 to 1500 pounds pressure p.s.i.) and practical hydraulic cylinder installation data. Included also is information on pressure losses due to friction and charts on the relations of cubic inch consumption, pipe size and velocities.



Your request on your company's letter head brings your copy promptly. Address—The Tomkins-Johnson Co., 618 N. Mechanic St., Jackson, Mich.

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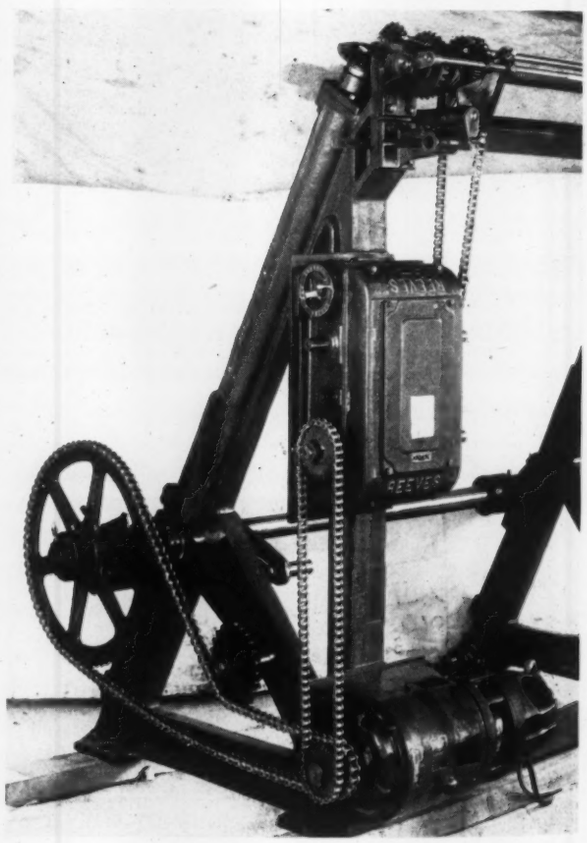
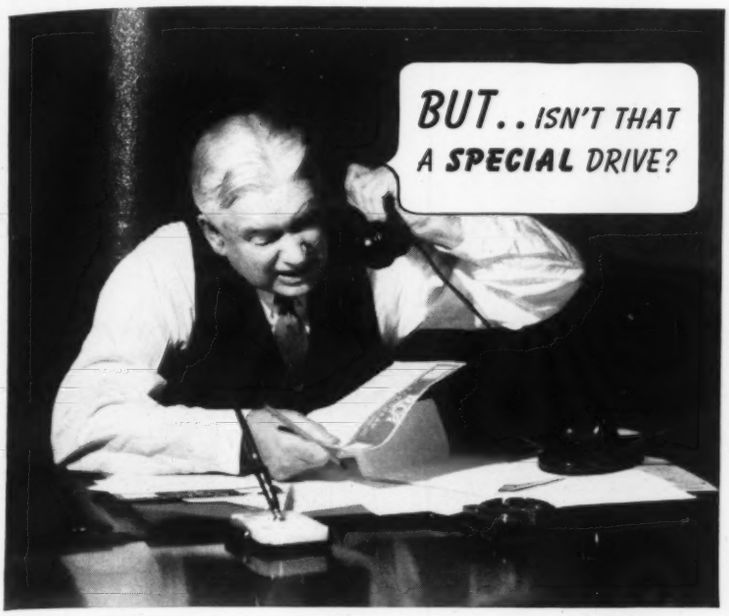
13 revolutions per minute output shaft speed is used at the source of power. This motor is a slip ring or wound rotor induction motor with windings to withstand stalled conditions. It was chosen because speed torque curves may be obtained to match the speed torque curves for various wire tensions by changing the amount of resistance in the secondary circuit. The torque curve or tension of the cable is controlled by a rheostat.

Another feature is the means used to drive the reel itself. The torque motor mentioned is connected to the main drive spindle by roller chain and V-sprocket. The reel is supported on a reel arbor and is driven by a reel dog and pin securely fastened to the reel arbor.

For quick and efficient operation it is essential that the operator may easily remove a reel and arbor without disturbing the drive and that the weight of the reel arbor to be handled be kept a minimum. This is accomplished by a clutch ar-



rangement. The drive sprocket rotates on a stationary sleeve which forms a part of the outboard bearing. The sprocket is secured to a short shaft by means of a cap or flange. Inside end of this short shaft is equipped with a male clutch which is slidable by means of a clutch lever. The motion is imparted by the worm thread cast in the hub of the clutch lever mounted on the outside of the male clutch. Reel arbor end is fitted with the female half of the clutch, and the two halves are easily brought into engagement or disengagement by the rotation of the clutch handle through a few degrees.



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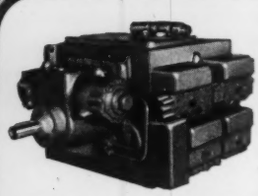

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Selecting Special Motors

(*Continued from Page* 40-S)

This is more easily visualized, in the case of *Fig. 2a*, if it is recognized that the high-speed connection is a single-circuit delta connection and the low-speed connection is a two-circuit *Y* connection with points 4, 5 and 6 forming the neutral. *Fig.* 4 illustrates schematically the principle of this type of pole-changing winding.

As has been mentioned previously, it is seldom practical to build motors with more than two stator windings. In general, two-speed motors with two stator windings consist mainly of motors having two speeds that do not bear a 2:1 ratio and, again as previously mentioned, of two-speed motors for two-phase power. In some instances, two windings are used for two-speed motors with 2:1 speed ratios. This is done to simplify the motor control in cases where control simplification is at a premium. For example, a single winding of the pole-changing type may require two five-pole contactors, whereas two independent windings

TABLE III

Relative Values of Horsepower and Torque

	Constant-Horsepower		Constant-Torque		Variable-Torque	
RPM	**H.P.**	**Torque**	**H.P.**	**Torque**	**H.P.**	**Torque**
1800	1	1	1	1	1	1
1200	1	1.5	.666	1	.444	.666
900	1	2.0	.5	1	.25	.5
720	1	2.5	.4	1	.16	.4
600	1	3.0	.333	1	.111	.333
514	1	3.5	.286	1	.0816	.286
450	1	4.0	.25	1	.0625	.25

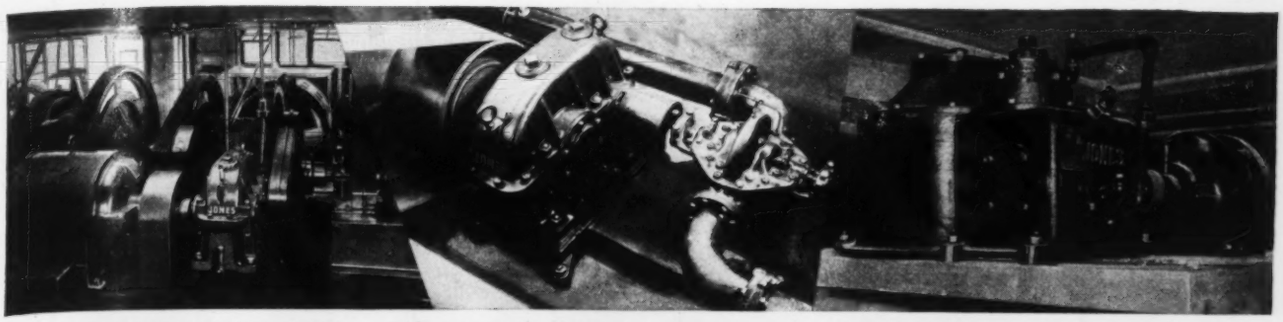
may only require two three-pole contactors. Two windings might also be used in preference to a single pole-changing winding where special characteristics of some kind are required for an unusual application.

In the case of the four-speed motor, both of its stator windings must be of the pole-changing type. Each winding will then produce speeds having a 2:1 ratio.

In the case of the three-speed motor, one of its windings should be of the pole-changing type and will produce two speeds which bear a 2:1 ratio to each other.

If a two-stator winding motor is not properly designed, injuriously high currents may be drawn from the power system even when the motor is running without any external load. These currents are called circulating currents and are caused by transformer action between the active and idle stator windings. Each primary winding must be designed so that when it is idle, the rotating field of the active primary winding does not induce currents to flow in any closed circuit within the idle winding. Voltages may be induced in the idle winding and may appear across its terminals without causing any trouble so long as these voltages are not induced in a closed circuit.

The delta of an idle winding or parallel cir-



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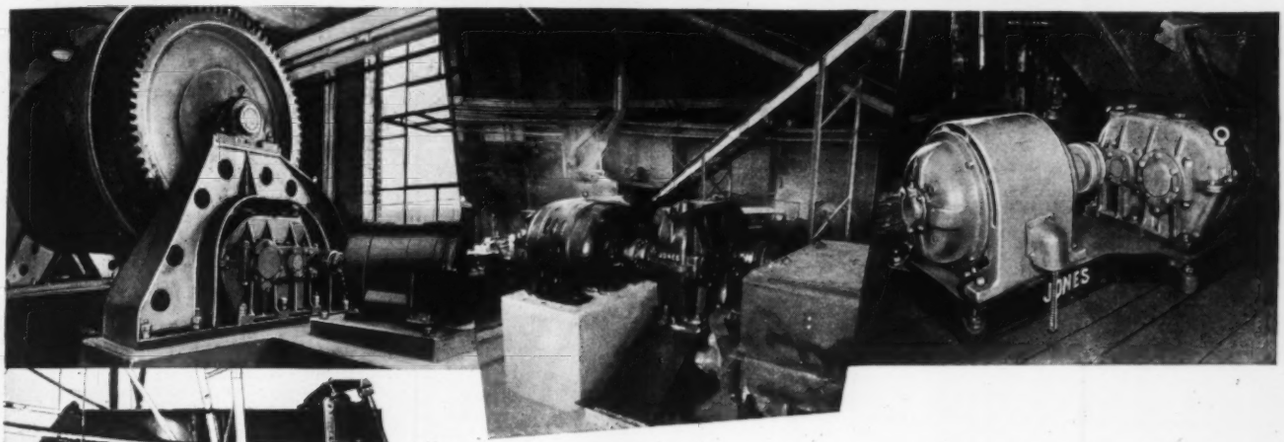

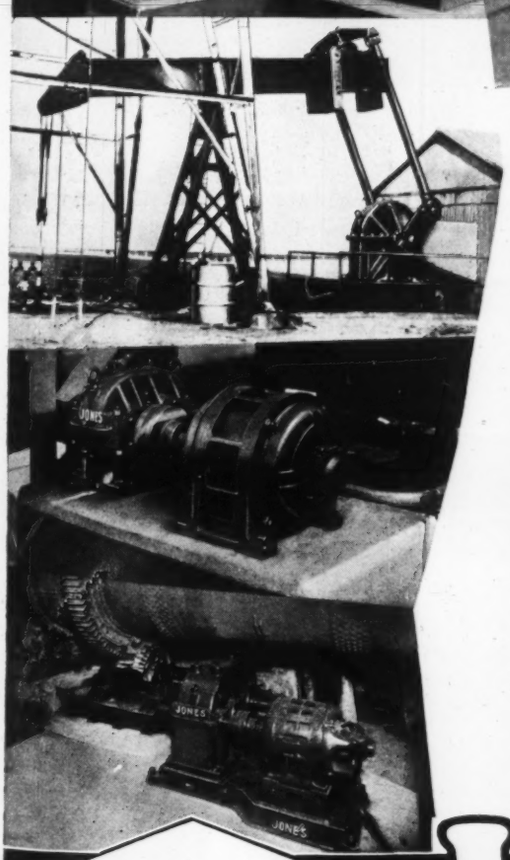

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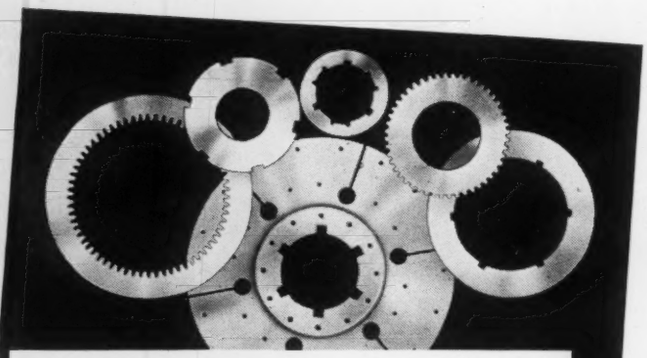

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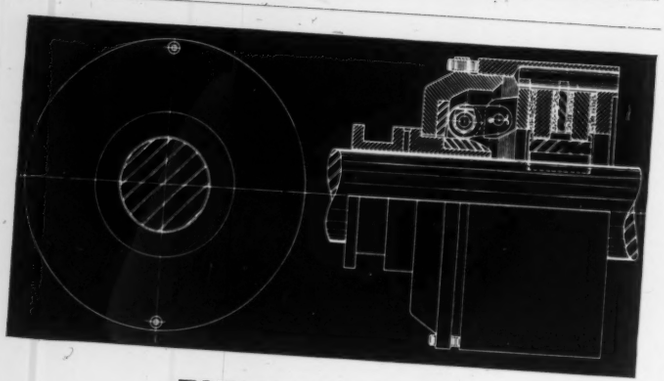

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cuits of an idle winding might be the closed circuit into which circulating currents might be induced. In some cases, in order not to sacrifice more important characteristics of the motor design, it is necessary to use a delta-connected winding even though circulating currents might be induced in it. In these instances, it is necessary to open the delta of this winding when it is idle. This is accomplished by means of an additional contactor in the control circuit.

Sometimes large horsepower multispeed motors for operation on relatively low voltage power circuits are practically impossible to design because of the problem of circulating currents in the multiple circuits of the idle winding. When a case like this occurs, a higher voltage at the motor terminals is recommended.

TABLE IV

Relative Maximum Output

Rating	Speed	Circuit Connection	Maximum Torque Output
Constant-horsepower	100	1—delta	100
	50	2—Y	117
Constant-torque	100	2—Y	100
	50	1—delta	66
Variable-torque	100	2—Y	100
	50	1—Y	22

Multispeed wound-rotor induction motors have been little used by machinery builders, principally because of the complication of the secondary control and the fact that the inherent speed regulation at reduced speeds is not always suitable.

However, two-speed, three-phase, wound-rotor motors with 2:1 speed ratios are practical to build. The rotors of these motors have six collector rings because the rotor winding, as well as the stator winding, is of the pole-changing type.

In *Fig.* 6 is shown a typical speed-torque curve of a polyphase squirrel-cage induction motor. The torque of the low-speed motor becomes negative above its synchronous speed. This torque slows down the motor and its load when the speed is changed from high to low. Also, the current is relatively high in this negative torque range and slowing down or decelerating the load during speed change is in effect an accelerating load.

In conclusion, it should be noted that the load imposed upon an induction motor may be considered to have two components. These two components are the working load and the accelerating load.

In cases where a motor does not start, stop, or change speed frequently, the accelerating load may be negligible. However, in cases where starting, stopping, or changing speeds is frequent, the accelerating load may become even larger than the working load.

In order that the motor designer can calculate the accelerating component of the load he must know the time cycle of duty imposed on the motor, the WR^2 of the external load, and the torque of the load over the entire speed range of operation.

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Perforated Disk Controls Sequence

(*Continued from Page* 41-S)

gle switch which starts a small gearmotor to rotate the spindle.

Included in the drive mechanism is a cam which opens a master air valve at periodic intervals. This valve admits air to an air chamber, inflating the diaphragm in the plunger head. Inflation of this diaphragm tends to make the plungers in the head move vertically downward.

Where there is a perforation in formula plate under a given plunger, the plunger which is indexed with the perforation passes through the plate and opens its corresponding valve in the valve series beneath the plate. This allows air to flow through a pilot circuit controlled by the given valve. The pilot circuits control admission of soap, bleach, blue and sour to the washer, and the opening and closing of main water valves and dump valves.

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In the base of the control unit are three supply tanks. The upper tank contains liquid soap, and arrangements are made so that five different amounts of soap can be added at five different times during the washing formula. This is accomplished by five siphon arrangements with five different-length internal siphon pipes. The siphons operate as follows:

When a pilot valve is opened, air is admitted to a small cylinder. Piston in the cylinder then moves downward and, in its movement, opens a spring-loaded check valve. The extension of the valve stem in turn opens a steam valve. This permits steam to flow through a steam tube, admitting steam to the siphon. This picks up the required soap, carries it through the unit and into a main supply line connecting with washer. The main supply line is connected to the water valves on the washer so that supplies are mixed with water before entering washer. This is important in quality washing as the supplies in solution go to work immediately. The method given for soap admission also applies to the introduction of all other supplies.

Floats installed in the supply tanks operate switches controlling signal lamps on the front panel of the control as shown in *Figs.* 1 and 2. An illuminated lamp indicates to operator that supplies are being fed into washer. When the proper amount of supplies has been introduced the lamp goes out.

Water level in washer is controlled by a diaphragm device shown behind and to the right of the plunger head in *Fig.* 2. Generally accepted washing formulas use three different water levels. The various levels are controlled by one of the pilot

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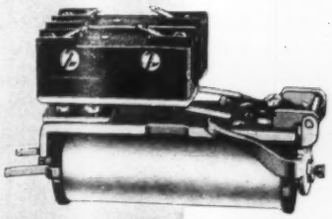

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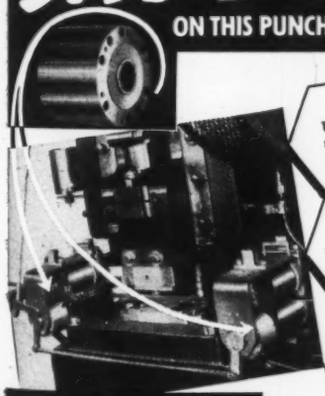

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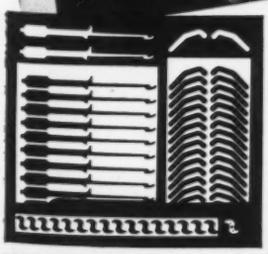

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valves in the valve series beneath the disk. This valve energizes the diaphragm device, which operates a secondary air circuit and sets a finger on a float-control device mounted between the washer and the control unit.

The valve in the main water line is the balanced type, air operated. With the valve open, water flowing into the washer raises a level in the float chamber. As the level reaches the predetermined water height it lifts the finger on the float chamber. This action shuts off the air supply to the water valve and closes the valve.

Since it is important that each particular bath run for a definite period of time after the correct water level is reached, the control automatically stops until the water reaches its correct level in the washer. As the water valve closes, the unit automatically restarts.

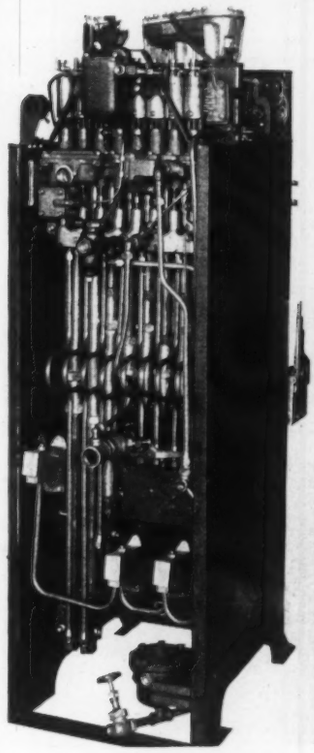

Fig. 3—Top view with cover removed showing diaphragm and plunger unit lifted to receive formula disk. Pilot valves, air cylinders and mercury switches are shown

On certain baths, accurate control of water temperature is also important. For this function another pilot valve beneath the disk controls a diaphragm-operated steam valve which is also controlled by a thermostat in the washer. This pilot valve opens the steam valve, admitting steam to heat the water. The thermostat then keeps steam valve open until the water is at the correct temperature. While the steam valve is open the unit automatically stops as in the case of filling with water.

At the completion of the washing formula a whistle is blown and a signal lamp lighted, notifying the operator that the formula is completed and washer is ready for unloading. The formula plate is then returned to the starting point by a spring, automatically resetting the formula for the next run.

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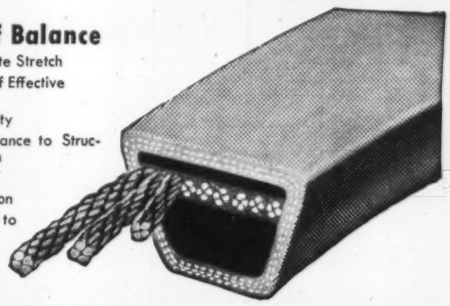

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EVERY item in the line of Ward Leonard Controls is an outstanding product of sound engineering, practical designing and careful manufacture . . . each planned to meet a specific set of conditions in industry. The absolute dependability and ruggedness of Ward Leonard Controls make them ideal controls to be built into machines and equipment the maintenance of which is expensive or difficult.

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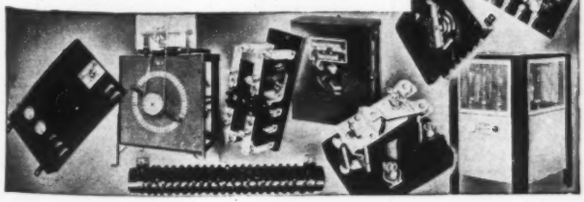

WARD LEONARD
54 SOUTH STREET MOUNT VERNON, N. Y.
ELECTRICAL CONTROL DEVICES SINCE 1892

Again PUSH-PULL CONTROLS *contribute to Speed with Safety*

Self-Aligning 8° deflection in both directions

Here you see PUSH-PULL CONTROLS used to operate brakes on a well-known industrial power truck—to give accurate braking or for emergency stops at the will of the operator.

☆

The same type of control is applied nationally to production machines, clutches, valves, switches and the like—and for the manual operation of many devices on which operating mechanism must be covered or is not within reach of the operator.

PUSH-PULL CONTROLS operate easily. Control is positive. They can be designed for instant, complete operation or to hold any position to which you set them. They don't become noisy or require adjustment.

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We have prepared an interesting booklet, *"The Key to Remote Control."* Write for a copy, telling us your problems.

PUSH-PULL CONTROLS
AMERICAN CABLE DIVISION
230 Park Avenue • New York

AMERICAN CHAIN & CABLE COMPANY, Inc.

Use New V-Belt Ratings

(*Continued from Page* 47-S)

belts with larger sheaves. Since the cost of sheaves lies not so much in the amount of metal used as in the cost of machining grooves, a considerable saving in first cost may be shown in the sheaves, not to mention the reduced cost of a smaller number of belts.

These tables are calculated for 180 degrees contact arc. Corrections should be made accordingly for shorter arcs. Naturally the correction applies only to the smaller sheave which determines the power transmitting capacity. Arc of contact for the small sheave is readily determined by the following:

$$\text{Arc} = 180 - \left(\frac{D - d}{c}\right) 60$$

where D is the diameter of large sheave; d, diameter of small sheave and c, center distance in inches.

Correction factors are shown in the following table, which also illustrates the effect of shorter arc on the power transmitting ability of V-belts.

To illustrate, costs may be compared on a par-

TABLE VI

Contact Arc Correction Factor

Degrees	Factor	Degrees	Factor	Degrees	Factor
180	1.00	150	.92	120	.83
170	.98	140	.89	110	.79
160	.95	130	.86	100	.74

TABLE V

Horsepower Ratings for E-Section V-Belts

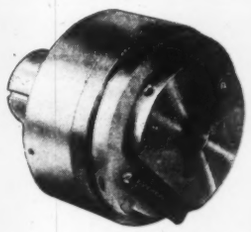
(Over 100 HP., 380 Lb. Belt Tension)

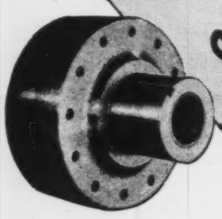
Velocity in Ft./Min.	Pitch Diameters								
	20.0"	21.0"	22.0"	23.0"	24.0"	25.0"	26.0"	27.0"	28.0" & larger
1000	8.0	8.5	9.0	9.4	9.8	10.2	10.5	10.9	11.1
1100	8.7	9.3	9.8	10.3	10.8	11.2	11.6	11.9	12.2
1200	9.5	10.1	10.7	11.2	11.7	12.2	12.6	13.0	13.3
1300	10.2	10.9	11.6	12.1	12.7	13.1	13.6	14.0	14.4
1400	11.0	11.7	12.4	13.0	13.6	14.1	14.6	15.0	15.4
1500	11.7	12.5	13.2	13.9	14.5	15.1	15.6	16.1	16.5
1600	12.4	13.3	14.1	14.8	15.4	16.0	16.6	17.1	17.5
1700	13.1	14.0	14.9	15.6	16.3	16.9	17.5	18.1	18.6
1800	13.8	14.8	15.7	16.5	17.2	17.9	18.5	19.0	19.6
1900	14.5	15.5	16.4	17.3	18.0	18.8	19.4	20.0	20.6
2000	15.2	16.2	17.2	18.1	18.9	19.6	20.3	21.0	21.6
2100	15.8	17.0	18.0	18.9	19.7	20.5	21.2	21.9	22.5
2200	16.5	17.6	18.7	19.7	20.6	21.4	22.1	22.8	23.5
2300	17.1	18.3	19.4	20.4	21.4	22.2	23.0	23.7	24.4
2400	17.7	18.9	20.1	21.2	22.2	23.1	23.9	24.6	25.3
2500	18.3	19.6	20.8	21.9	23.0	23.9	24.7	25.5	26.3
2600	18.9	20.2	21.5	22.6	23.7	24.7	25.5	26.4	27.1
2700	19.4	20.8	22.1	23.3	24.4	25.4	26.4	27.2	28.0
2800	19.9	21.4	22.8	24.0	25.1	26.2	27.1	28.0	29.0
2900	20.4	22.0	23.4	24.7	25.8	26.9	27.9	28.8	29.7
3000	20.9	22.7	24.0	25.3	26.5	27.6	28.6	29.6	30.5
3100	21.4	23.0	24.5	26.0	27.2	28.3	29.4	30.4	31.3
3200	21.8	23.5	25.1	26.5	27.8	29.0	30.1	31.1	32.0
3300	22.3	24.0	25.6	27.1	28.4	29.6	30.7	31.8	32.8
3400	22.6	24.5	26.1	27.6	29.0	30.2	31.4	32.5	33.5
3500	23.0	24.9	26.6	28.1	29.5	30.8	32.0	33.1	34.2
3600	23.4	25.3	27.0	28.6	30.0	31.4	32.6	33.8	34.8
3700	23.7	25.6	27.4	29.1	30.6	31.9	33.2	34.4	35.5
3800	24.0	26.0	27.8	29.5	31.0	32.4	33.7	34.9	36.1
3900	24.2	26.3	28.2	29.9	31.5	32.9	34.3	35.5	36.6
4000	24.5	26.6	28.5	30.3	31.9	33.4	34.7	36.0	37.2
4100		28.8	28.8	30.6	32.3	33.8	35.2	36.5	37.7
4200		27.1	29.1	30.9	32.6	34.2	35.6	37.0	38.2
4300			29.3	31.2	33.0	34.6	36.0	37.4	38.7
4400			29.5	31.5	33.3	34.9	36.4	37.8	39.1
4500				31.7	33.5	35.2	36.7	38.2	39.5
4600				31.9	33.7	35.5	37.0	38.5	39.9
4700					33.9	35.7	37.3	38.8	40.2
4800					34.1	35.9	37.5	39.1	40.5
4900						36.0	37.7	39.3	40.7
5000						36.2	37.9	39.5	40.9

Memo when ordering clutches Specify Hilliard because ① 35 yrs. experience ② simple in design ③ sound engineering ④ automatic-accurate etc

from One Engineer to Another . . .

these clutches do the job!





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An over-running or "free-wheeling" clutch of remarkably simple design. Drives when rotation is in one direction—runs free when rotation is reversed, or one member runs ahead of other. Wear on flat surfaces only, renewable 4 times, without requiring new parts. "Standard Equipment" for: Automatic dual drive operation of any equipment with any type of prime movers* Automatic operation of 2-speed drive* As a ratchet permitting infinite adjustment* As an automatic backstop.

WRITE TODAY

To learn how Hilliard will adapt these clutches to *your* needs

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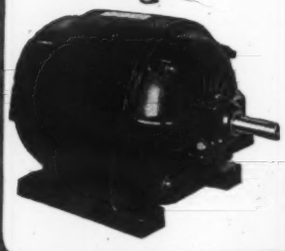
MOTORS
Tailored to fit your Needs

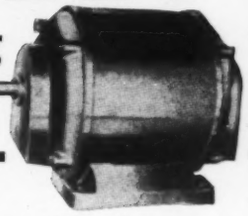


MANY times a motor with standard windings is not the best motor for the job. Or a change in frame design or size means a better application to your product.

Peerless is equipped to handle large or small orders of any special design that will give you maximum motor efficiency, trouble-free operation and minimum upkeep. Send us your motor problems. 47 years of building motors have given Peerless engineers experience in meeting any motor problem.

THE *Peerless* ELECTRIC CO.
WARREN, OHIO

VALLEY
Ball-Bearing MOTORS



The Choice of Leading Design Engineers

DRIP PROOF—SPLASH DESIGN

Valley Ball-Bearing Motors are designed to meet operating conditions where hazards of liquids, chips etc., dropping into the motor, are involved. Motors are protected against this as well as against normal splash conditions.

. . . *because BETTER MOTOR DESIGN* has been the consistent aim of Valley Electric Corporation engineers throughout the years. The Valley Ball-Bearing Electric Motor of today offers definite buyer-appeal in efficiency and economy to the purchasers of your equipment. That is why prominent design engineers are incorporating Valley Ball-Bearing Motors in their plans.

Consider the importance of these five outstanding features when you order your next motor. (1) No Dead Spots. . . . (2) Efficient and Ventilated Winding. . . (3) 40° C. Maximum Temperature Rise. . . (4) Squirrel-Cage Welded Rotors. . . (5) Ball Bearings.

Ball-Bearing Motors
½ to 75 Horsepower

Valley ELECTRIC

VALLEY
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TODAY
Answering a Lot of Problems
in REMOTE CONTROL
& Power Transmission
STOW Flexible Shafts

No. 234 Type R .200 dia. R. H.
No. 254 Type R .200 dia. L. H.
No. 210 Type R .250 dia. L. H.
No. 210 Type R .250 dia. R. H.
No. 255 Type R .312 dia. R. H.
No. 255 Type R .312 dia. L. H.
DEFLECTION—DEGREES PER FOOT
TORSIONAL LOAD—Lb. In.
0 1 2 3 4 5 6 7 8

• Here in this graph you have Load-Deflection data on one specific type of STOW core . . . typical of technical information on 19 separate standard sizes available for your particular requirements. Type R (per diagram) is used for both remote control and power transmission at low speeds. Other cores range from 1/16" to 15/8" diameter . . . with power capacity up to 140 ft. lbs. All of them the result of 65 years' experience by STOW—the inventors of Flexible Shafting. Consult the STOW Engineering Service about your application. Write today . . . no obligation, strict confidence.

STOW MANUFACTURING COMPANY, INC.
11 SHEAR STREET BINGHAMTON N. Y.

ticular 40-horsepower motor drive recently furnished to a fan manufacturer. The motor operates at 1160, driving a fan at 380 revolutions per minute on approximately 40-inch centers. From the rating tables, using the smallest practical sheave for *C*-section belts, a suitable drive comprises twelve belts, each belt approximately 120 inches long with a 7-inch pulley diameter motor sheave and a 21.4-inch pulley diameter fan sheave. This drive has a cost of $196.80.

Using larger sheaves for comparison, a better selection of a drive for this fan would be 5 belts with a 12-inch pulley diameter motor sheave and a 36.6 pulley diameter fan sheave. This drive has a cost of $137.72.

From the comparison it will be seen that first cost is a vital factor in this case, having saved $59.08 or over 40 per cent. Only when there are limitations on space and belt speed would it be necessary to use the more expensive drive with smaller sheaves.

When belt replacement becomes necessary, the above drive with larger sheaves again has the advantage by $17.64 which represents a further saving of over 85 per cent in the cost of replacement belts.

This does not mean that a drive will not operate successfully with small diameter sheaves. There are times when it is impractical to install sheaves of large diameter. It does mean, however, that because of greater flexing the drive with the smaller 7-inch pulley diameter *C*-section sheave will have only one-half or one-third of the belt life that may be expected from the 12-inch pulley diameter sheave. This is the basis on which the new ratings are compiled.

There is another important factor that has not been mentioned up to now. It is "tension" and is entirely under the user's control.

In compiling all the V-belt ratings, certain definite tensions were used for each size of belt as established by laboratory test. These tensions must be maintained to get the greatest efficiency from a V-belt drive and are tabulated in TABLE VII.

TABLE VII

Recommended Belt Tensions

Sections	Pounds per Belt
A	40
B	70
C	125
D	230
E	380

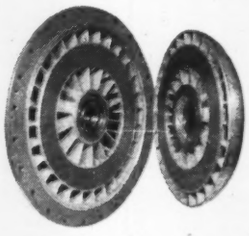
If we should happen to have a drive with one-groove *C*-section sheaves (any size) with a tension of 125 pounds between the sheaves, the drive will pull the rating given in the table. If it is a two-groove drive, the tension is 125 pounds on each belt or a total of 250 pounds; or on a nine-groove drive the tension should be 1125 pounds.

When a machine is designed to do a certain job, space and mountings for the motor are no more important than the proper drive.

CHICAGO FLOATING SWING BRIDGE HAS SMOOTH FLUID DRIVE

Chicago's 130th Street traffic is moving more steadily, with shorter waits at the Calumet River Bridge for boats —thanks to Fluid Drive!

The American Blower Fluid Drive (Hydraulic Coupling) is installed between the gasoline engine and gear box that delivers power to the winch for the 105-ft. pontoon swing span. Operators can now control the bridge movement entirely by regulating the engine throttle and without manipulating the drum clutches of the winch. Engine stalling and clutch burnouts are eliminated. The cables, machinery and engine are protected from sudden jerks and stresses. Handling of the bridge is simplified and speeded up . . . All by the American Blower traction type Fluid Drive!



Fluid Drive

(HYDRAULIC COUPLING)

Have you investigated American Blower Fluid Drives (Hydraulic Couplings) for your plant or product? You're overlooking a real bet if you don't consider their many advantages for your own problems of torque transmission and speed control from either electric motors or internal combustion engines. Phone or write the nearest American Blower branch office now for complete data.

AMERICAN BLOWER CORP.

HYDRAULIC COUPLING DIVISION, 6000 Russell St., Detroit, Mich.
New York: 50 W. 40th St., Room 402 • In Canada: Canadian Sirocco Co., Ltd.

MACHINE DESIGN *Editorial*

New Machines Are Only Answer to Call for Production

HOW far can we go in assuming that improvised or rejuvenated equipment is capable of handling the production end of our armament program? From certain quarters comes the suggestion that rather than design and build special machines we should utilize existing equipment; that by doing so we not only would be able to take care of vital defense requirements but could return the machines to their normal line of production when the emergency is over.

To MACHINE DESIGN this idea seems basically unsound except as an expedient to carry along at least some production until such time as new machines can be developed and built. One need only consider, as a prime example, the special shell lathe covered in the leading article in last month's issue. That machine was designed as a single-purpose unit of sufficient rigidity, horsepower and capacity to produce shells at a speed far higher than any other existing type of machine. It would be not only impractical but almost impossible to adapt other machines to take care of a similar high rate of production.

Apart from the fact that relatively few lathes are equipped with motors of sufficient horsepower to remove metal at the rate of speed possible with the special shell lathe, the question of continued availability of skilled or semiskilled labor should be considered. Machines that might be adapted to the job require, in most cases, at least semiskilled labor for their operation. The new defense-program machines are developed specially for operation by men—or women—who after only brief training can operate them satisfactorily under capable supervision. This point may seem relatively small at the moment but the call for operators in the entire metalworking industry in the near future will unquestionably make the operator problem one of ever-pressing importance.

Initial costs and maintenance costs also enter into the picture. New, specially built machines call for initial outlay. On the other hand, maintenance costs and rate of production of the new machines will readily overcome the seeming economy of trying to "make do" with converted machines that are either good enough to be busy already on other essential jobs, or are in such condition as to be practically ready for the scrap pile.

As a temporary measure, yes. Old or even new machines, wherever obtainable, should be turned over to armament production, remembering that a low rate of speed is better than none. But as a long range program, the need for which is becoming more increasingly apparent, there seems no question that new designs capable of handling our defense needs should be given a clear right-of-way. The design brains are available—why not utilize them to the utmost in the unprecedented program with which the country is confronted?

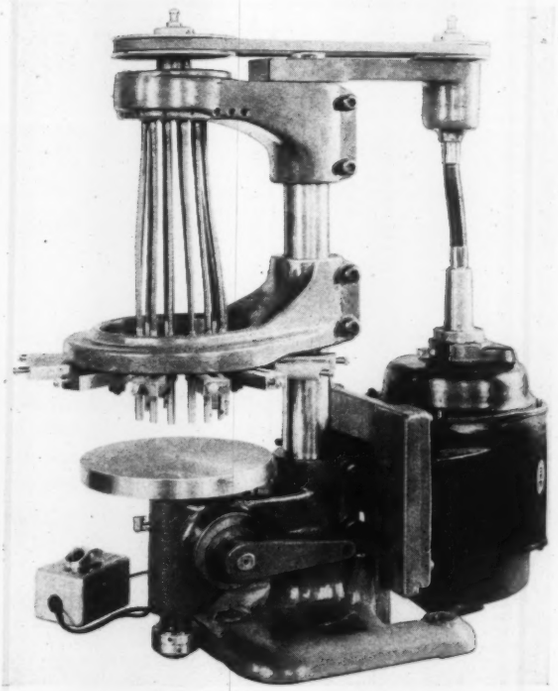
Applications

OF ENGINEERING PARTS AND MATERIALS

Enables Drills To Be Positioned

EXTREME flexibility built into this multiple-spindle drill press is made possible by the use of flexible shafts. Each of the twelve drill holders is connected to its driving spindle by a length of this S. S. White shafting, enabling each drill to be positioned in the built-in jig over a wide range of adjustments.

With this equipment it is possible to drill any number of holes up to twelve, of any size within the limits of the press, in any desired arrangement.



Flexible shafting enables this press to drill up to twelve holes at a time in any relative position

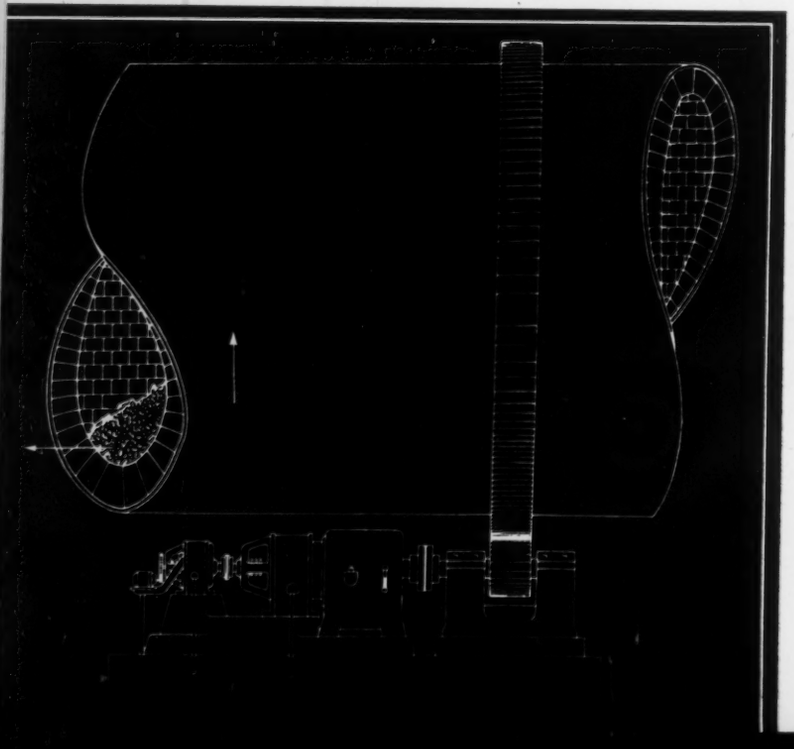
Cement Kiln Drive Improved

HEAVIER duty service than that involved in cement kiln application of a gearmotor drive is difficult to imagine. Weighing over 300 tons, the kiln shown is rotated at from 45 to 60 revolutions per hour. through a gear reduction of approximately 900 to 1.

Designed especially for this application by the General Electric Co., the reduction is self-contained with the adjustable speed motor. All planetary gearing in the unit operates in a sealed bath of oil.

Nearly seven inches in diameter, the output shaft is required to operate the kiln pinion shaft at 7 revolutions per minute. A pinion on this shaft engages the ring gear which extends entirely around the kiln.

Fully enclosed gearmotor provides compact and economical drive for cement kiln

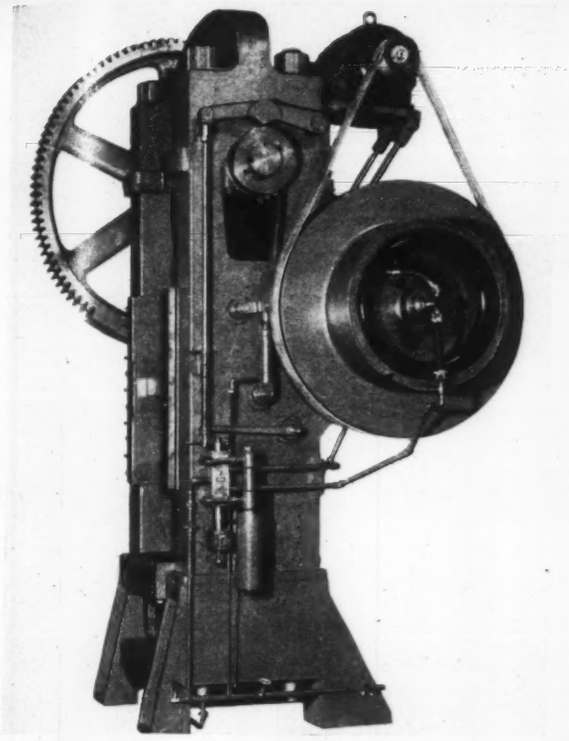


Clutch Absorbs Torsional Vibration

SEVERE clutch and braking problems encountered in the design of the Rockford 250-ton crank type press were solved successfully by use of the Airflex clutch. Both the clutch and brake are of the internal expanding type and co-act with internal cylindrical surfaces on either side of the flywheel. Because of the large mass of this member and consequent high heat capacity, operating temperatures are extremely low.

An interesting feature of these clutches is the absorption of torsional vibrations by the flexible sidewalls. Also, by varying the operating air pressure the ability of the clutch to prevent transmission of such vibrations may be enhanced without in any way detracting from its efficacy as a clutch or brake.

Utilization of an air dashpot built into the C. B.



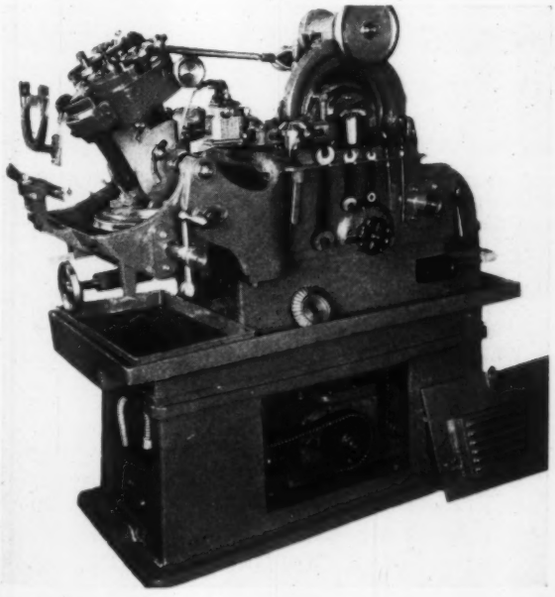
Long life, absorption of vibration and absence of mechanical linkages typify air-operated clutch

Hunt control valve provides the necessary time delay between the release of the clutch and the application of the brake.

Provides Continuously Variable Speed

POSITIVE, infinitely variable speed changes are provided for in this bevel gear generator by use of a Link-Belt speed control. This newly designed machine affords the same speed range of 45 to 180 strokes per minute as formerly. However, it was previously necessary to stop the machine and select one of eight available speeds within the range. The new transmission permits the machine to be operated at an infinite number of speeds which may be selected while the machine is in operation. The gear generator is made by the Bilgram Gear and Machine Works.

Infinitely variable speed gear transmission increases productiveness of gear generator

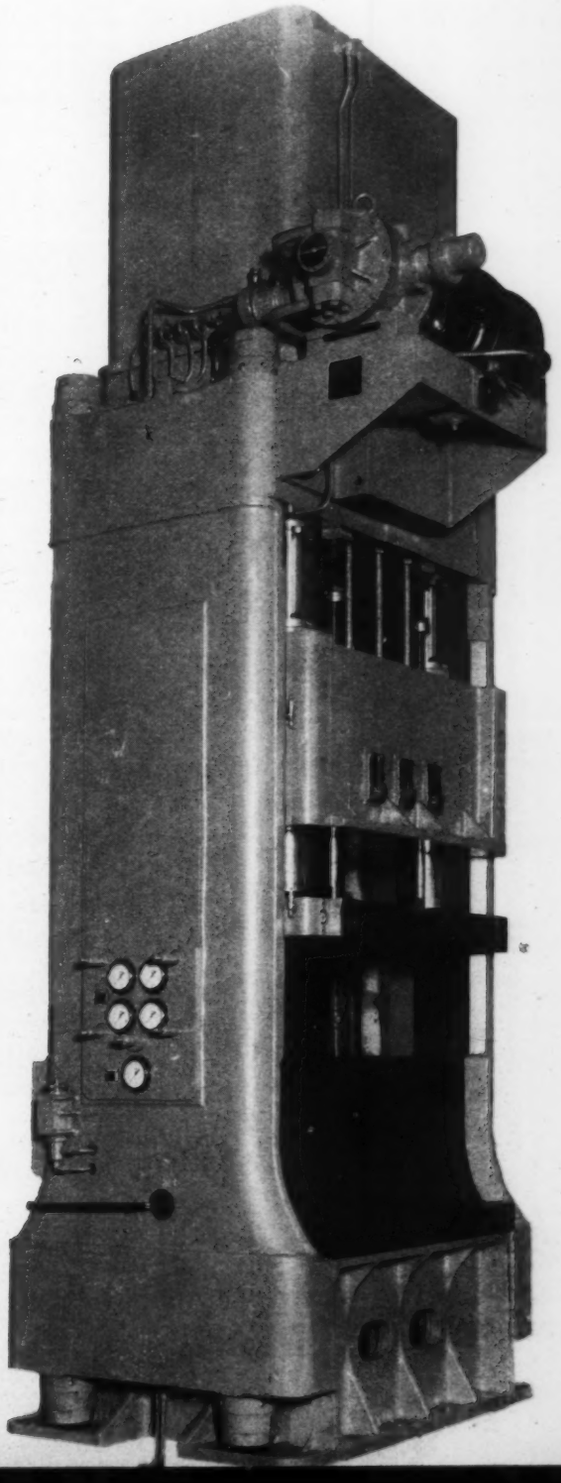


Built-in Filters Improve Operation

FOR maximum efficiency and proper lubrication of all working parts it is desirable that the viscosity of the operating oil in hydraulic presses be maintained within suitable limits. This is accomplished by the Hydraulic Press Manufacturing Co. with temperature controllers and an efficient method of fluid filtration.

Heavy duty Cuno oil filters are installed in each closed-circuit operating system. Provided with an external handle for periodic cleaning, the filter is equipped with sump and drain to permit cleaning without dismantling.

Continuous filtration of working fluid assures uninterrupted, trouble-free press operation



Men of Machines

HERBERT S. SIMPSON

NOMINATED for presidency of American Foundrymen's association, of which he is now serving as vice president, Herbert S. Simpson has been connected with the foundry and foundry equipment industry for many years. His father before him had spent his life in the foundry and machinery business.

A native of Minneapolis, Mr. Simpson finished his education and became engaged in the manufacture of clay-working machinery. Later he was made assistant to the president of Hatfield-Penfield Steel Co. He left this company to become associated with National Engineering Co., manufacturers of sand mixing, conditioning and other foundry equipment, of which organization he has been president since its incorporation. Mr. Simpson is a past director of American Foundrymen's association, and a past president of the Foundry Equipment Manufacturers' association. He has also supported various research activities of the A. F. A.

PETER ALTMAN

A PIONEER in the field of aeronautical engineering, Peter Altman has resigned as director of the aeronautics department of the University of Detroit to become associated with Aviation Mfg. Corp. in its research and development division.

Mr. Altman received his bachelor of aeronautical engineering degree from the university and since graduation has been connected there. He first was employed as instructor in the department of experimental engineering and later was placed in charge of the aeronautics department. In addition to this work he devoted considerable time to design and consulting for leading aircraft companies, one of his projects being that of making drawings of the first Stinson biplane and later the cabin biplane with wheel control and brakes. He also worked on the early Stinson monoplanes and other designs, and assisted in all of this company's experimental and test programs. He has been consultant for Stinson ever since.

LYNN REYNOLDS

APPOINTMENT of Lynn Reynolds as chief engineer of Adel Precision Products Corp., manufacturers of airplane synthetic rubber materials and hydraulic accessories, marks his return to the aviation engineering field. Mr. Reynolds formerly was metallurgical engineer of Worthington Pump & Machinery Corp.

A graduate mechanical engineer of Stanford university, Mr. Reynolds received his early aviation training as one of the first U. S. Army inspection engineers on the West coast. Early in the first World war he became aeronautical mechanical engineer for the National Advisory committee for aeronautics, and later was transferred to the national aviation engine and plane preparedness development program. The last year of the war found him with the rank of Captain Aviation Unattached, U. S. N. A., as assistant to the chief engineer for the A. E. F. aviation section in France.

In the interim—after the war and prior to his present appointment—

(*Continued on Page* 88)

THIS NEW TRACING CLOTH *IS*

GHOST-PROOF!

Here is a new kind of tracing cloth that won't show perspiration stains or water marks—*that holds pencil smudges and erasure scars at a minimum.* Now you can have clean tracings, in pencil or ink, free from these untidy "ghosts" that reproduce on blueprints!

For PHOENIX is ghost-proofed by a remarkable new process that defies moisture, and gives you an unusually durable working surface. You can use harder pencils with this improved cloth and get sharper lines with less tendency to smudge. Even 6H pencil lines show clearly, and reproduce sharply! Erasing does not mar the drawing surface; erased areas take pencil smoothly—and ink without feathering. The new white color and increased transparency provide excellent drawing contrast and produce strong blueprints.

Try PHOENIX for yourself on your own drawing board. See your K&E dealer or write for a generous working sample and an illustrated brochure.

PHOENIX DEFIES MOISTURE GHOSTS . . .

Your hands are never dry. Perspiration stains ordinary tracing cloth, producing opaque spots, or "ghosts," that show on blueprints. Water splashes make even more disagreeable stains.

PHOENIX *Tracing Cloth withstands actual immersion in water for more than 10 minutes at a time without ill effects!* Perspiration will not stain it!

PHOENIX LESSENS SMUDGE GHOSTS . . .

The improved surface of PHOENIX Tracing Cloth permits you to use harder pencils (5H and 6H) and to get sharper lines with less tendency to smudge.

Result: cleaner tracings and blueprints!

PHOENIX REDUCES ERASURE GHOSTS . . .

Ordinary tracing cloths become scarred when erased. Erased spots produce ghosts on the blueprints.

PHOENIX has a durable drawing surface that reduces working scars to a minimum.

K&E

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TRADE MARK

TRACING CLOTH

EST. 1867

KEUFFEL & ESSER CO.

NEW YORK • HOBOKEN, N. J.

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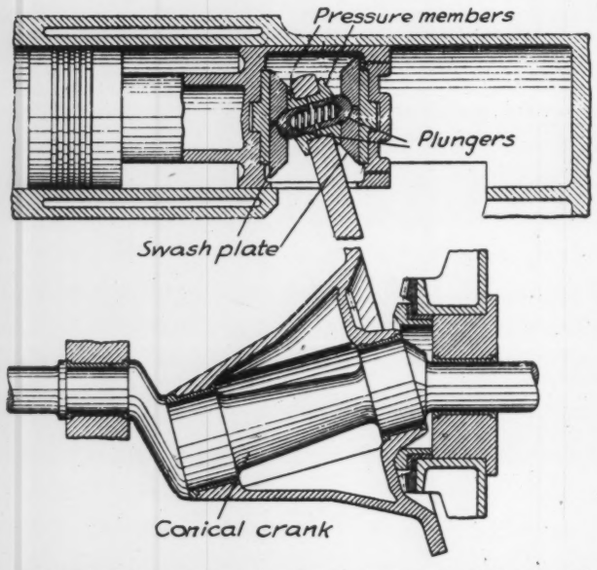
Noteworthy PATENTS

Swash Plate Loading Redistributed

WEAR resulting from maldistribution of swash plate bearing loads has been the chief disadvantage of pumps, engines, etc. utilizing reciprocating pistons parallel to crankshaft axes to produce rotation. In a patent assigned to the Naamlooze Venootschap, the cause of the phenomenum as well as design criteria for its correction are derived from the application of basic engineering principles.

To compensate for wear, the conical surfaced pressure members are bored out to contain a pair of opposed springloaded plungers with spherical ends. As the swash plates, or slippers on which they bear, wear, the plungers extend as a result of the spring load so looseness does not develop in the assembly.

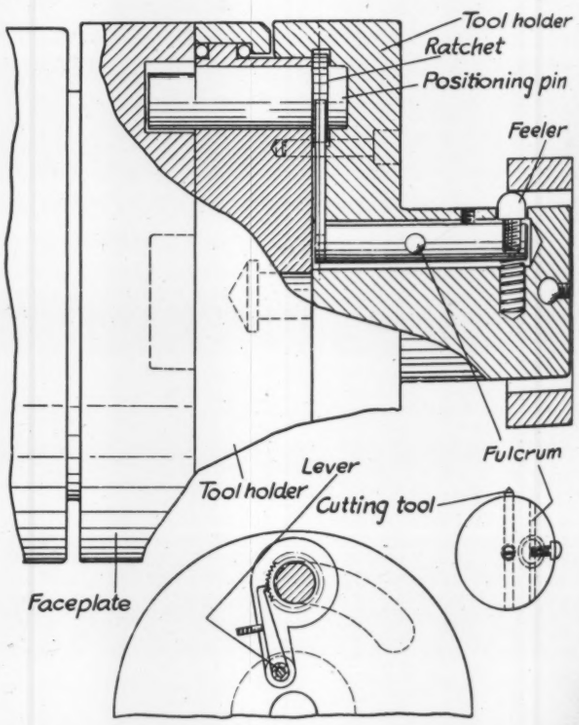
The critical bearing surface is that between the conical surfaces of the pressure members and the swash plates. Excessive wear is experienced on this surface in the region of the large or base diameter of the cone. Application of Stribeck's principle governing load intensities under conditions of rolling contact indicates that, as a result of the greater radius of curvature at the outer extremity of the cone generatrix, stress concentrations are a maximum in this region. By assuming that the conical surface is composed of a large number of rollers of differential length, the diameter of each roller (assumed constant) is determinable as a function of its length. By Stribeck's relationships, therefore, the optimum dimensions of the pressure members may be obtained,



Spring-loaded plungers afford automatic take-up of wear, thus eliminating "knocking" in swash plate

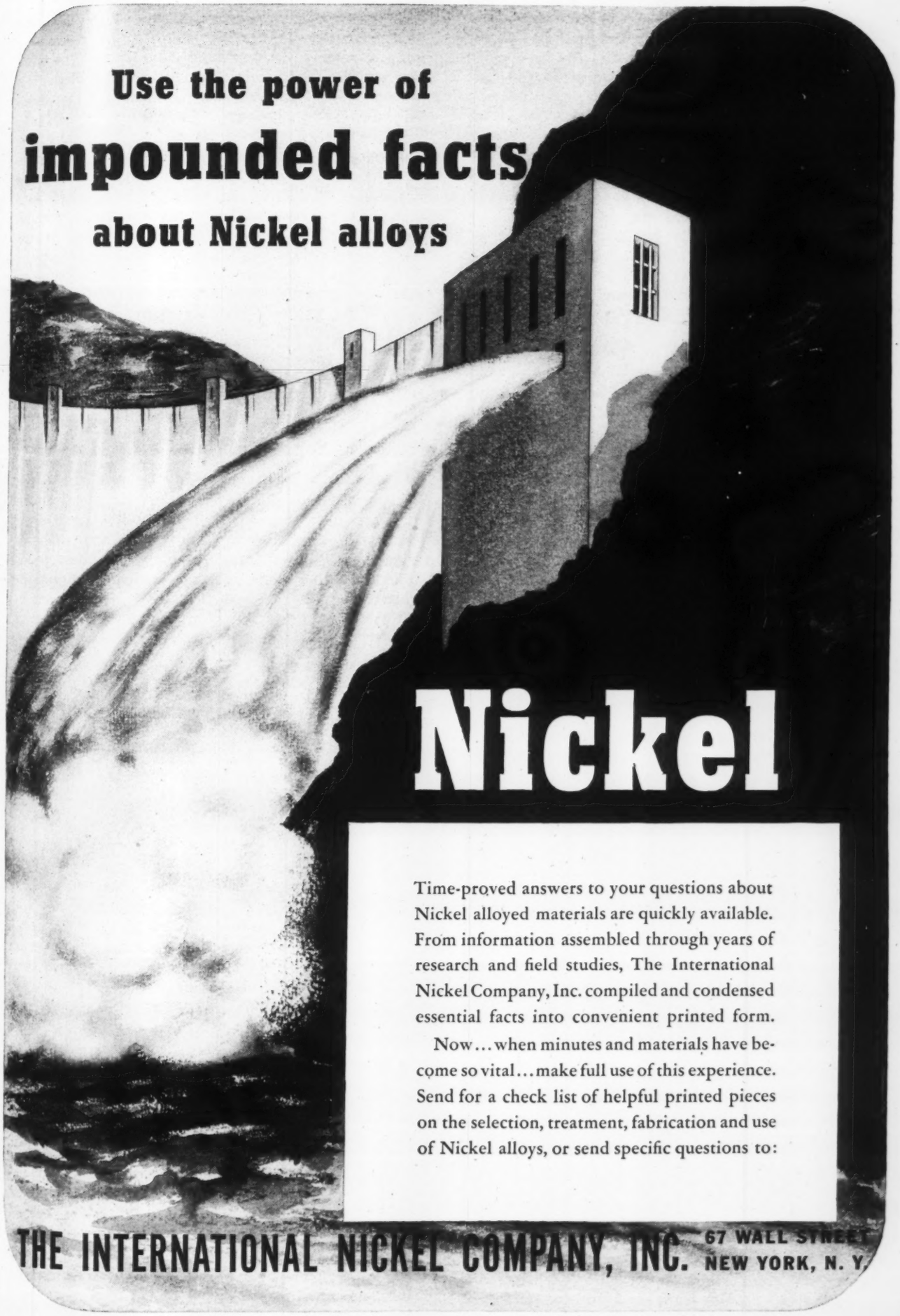
Compensates for Tool Wear

VARIATION from a specified finished bore diameter is, ordinarily, the inevitable consequence of cutting tool wear. This patent discloses a means for automatically feeding the boring tool radially to compensate for such wear and, at the same time, removes the tool from contact with the bore at the conclusion of the cut so that it may be retracted without marking the work. The device is applicable to automatic precision borers manufactured by the Heald Machine Co., to which the patent is assigned.



Relative location of cutting tool and feeler on spindle enables tool to be advanced or retracted without destroying gaging accuracy

Eccentrically mounted in ball bearings on the face-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impounded facts
about Nickel alloys
Nickel
Time-proved answers to your questions about Nickel alloyed materials are quickly available. From information assembled through years of research and field studies, The International Nickel Company, Inc. compiled and condensed essential facts into convenient printed form.
Now... when minutes and materials have become so vital... make full use of this experience. Send for a check list of helpful printed pieces on the selection, treatment, fabrication and use of Nickel alloys, or send specific questions to:
THE INTERNATIONAL NICKEL COMPANY, INC.
67 WALL STREET
NEW YORK, N. Y.

plate, the rotation of the tool holder with respect to the faceplate is limited by a positioning pin which extends into a slot in the plate.

As the faceplate rotates, the inertia of the tool holder holds the positioning pin eccentric against the trailing end of the faceplate slot. At the conclusion of the cut, the spindle is stopped and the inertia moves the tool holder in the direction of rotation to the other end of this slot. Since the tool holder is eccentric on the faceplate the tool is thus backed away from the work surface and may be retracted.

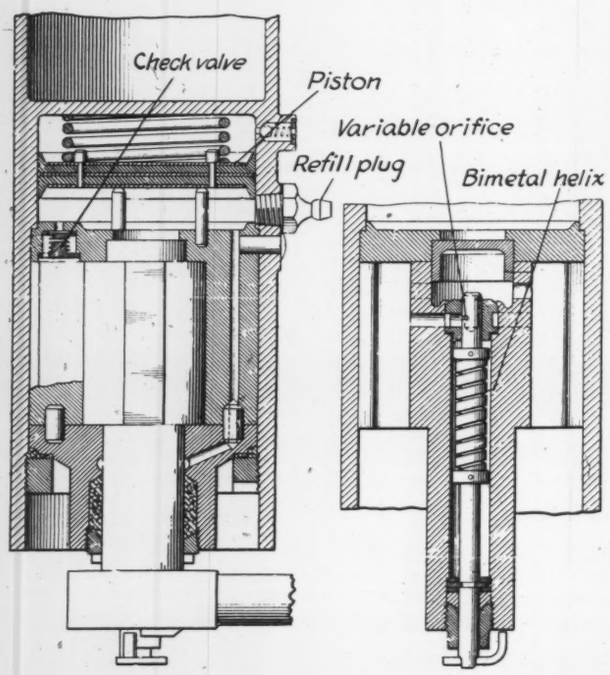
Located in the tool holder but displaced 90 degrees from the tool is a hemispherical feeler mounted on the end of a lever. Fulcrumed at approximately its midposition, this lever has a pawl fastened to its opposite end. The pawl engages a ratchet integral with the positioning pin.

While the tool is cutting the feeler is in constant contact with the bore of the work. As the tool wears the diameter of the bore decreases, depressing the feeler. The pawl on the other end of the lever thus rotates the positioning pin, causing its eccentric to displace the tool holder with respect to the faceplate and thereby restoring the proper bore diameter.

Corrects for Temperature, Leakage

LEAKAGE of hydraulic fluid from shock absorbers as well as its change in viscosity as a result of temperature variations detract from the operating efficiency of such devices. This patent, assigned to the Houde Engineering Corp., discloses methods whereby both of these conditions are remedied.

Illustrated is a rotary type of shock absorber in which diametrically opposite partitions fastened to the cylinder walls co-operate with similar partitions fastened to a hub or shaft. Confined between the cylinder head and a spring-loaded piston is a replenishing chamber. This chamber may be filled with a reserve of hydraulic fluid through a refill plug which is a conventional lubrication fitting.



Lever on valve stem concentric with mainshaft permits selection of desired damping force

Between the replenishing chamber and the chambers formed by the partitions on hub and cylinder wall are a series of check valves. As fluid leaks from the operating chambers these valves permit hydraulic fluid from the replenishing chamber, under the impetus of the piston, to enter the operating chambers. As a means of reducing leakage an annular recess is formed inside the shaft packing and is connected by drillings to the replenishing chamber.

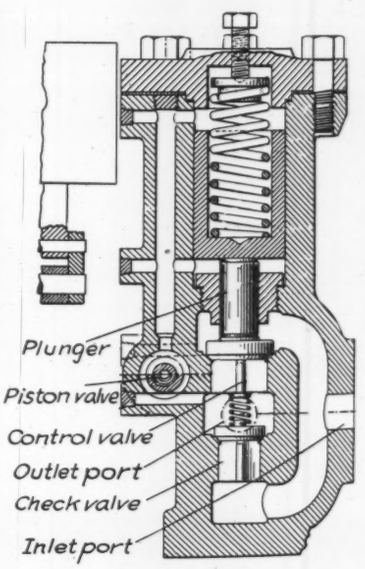
Shown in the illustration on the right is the device for compensating for fluid viscosity changes. Concentric with the operating shaft is an adjustable metering valve stem. A portion of this stem consists of a bimetal helix which, as the temperature of the hydraulic fluid changes, regulates the size of a slot orifice in the by-pass between the working chambers.

Controls Hydraulic Press Operation

IN FORMING sheet metal parts on hydraulic presses it is often disadvantageous that the fast approach of the ram to the work is not impeded until actual contact occurs. Valve, disclosed in this patent assigned to the E. W. Bliss Company, provides, in conjunction with solenoid control, means of eliminating impact.

Reverse fluid flow, i.e., from the outlet port through the inlet port, is substantially unimpeded. The check valve, which is loaded by a light helical spring, opens under a nominal pressure load thus facilitating rapid retraction of the press ram.

Free reverse flow is permitted by lower poppet. Piston valve controls pressure above plunger



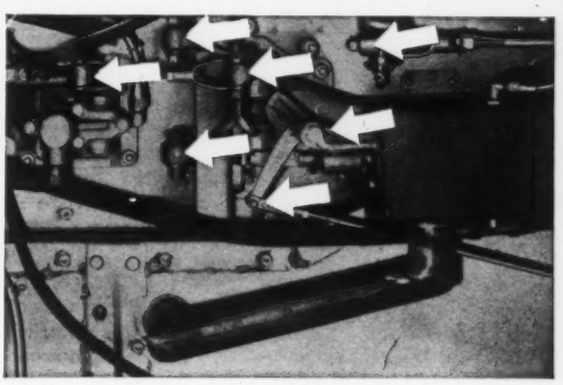
For regulated flow the upper or control valve is used. A plunger which is carefully fitted in a plug fastened in the valve body transmits spring and piston thrust to the poppet. In order to regulate this thrust, provision is made for subjecting the upper and lower areas of the piston to both upstream (high) and downstream (low) pressure bias.

TORRINGTON NEEDLE BEARINGS INCREASE EFFICIENCY,

REDUCE COSTS ON WHITE

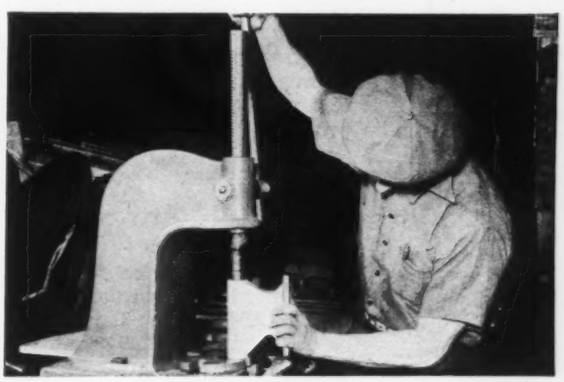
SUPER POWER TRUCKS, BUSSES, AND FAMOUS WHITE HORSE

1 ANTI-FRICTION TORRINGTON NEEDLE BEARINGS are widely used in the construction of White Super Power Trucks and Busses because they withstand heavy loads, provide anti-friction operation in small space. Radial load capacity is unusually high in proportion to the size of the Needle Bearings.



2 UNDER SIDE OF WHITE BUS reveals 7 Torrington Needle Bearings on controls. Their anti-friction qualities allow utmost freedom in movement of levers, rods and arms and permit long control rods to move freely without binding. Photo shows how easily bearings fit in limited area.

3 NEEDLE BEARINGS are utilized on folding door of White Horse quick-delivery truck. They permit doors to operate freely in any weather. No extra lubrication system is necessary as the bearings store large supplies of oil or grease. Because Needle Bearings last longer, maintenance is substantially diminished.



4 INSTALLATION OF TORRINGTON NEEDLE BEARINGS is simply and economically accomplished on a regular arbor press. In the intermediate clutch relay shaft bracket (shown above) as in many other applications, the compactness of Torrington Needle Bearings cuts costs by reducing size and weight of surrounding parts.

If your product can be improved by a bearing with high load capacity, unusually small size, quick installation, and efficient lubrication, investigate the advantages of the Torrington Needle Bearing. Our Engineering Department will be glad to work with

you in incorporating its advantages in your product. For more detailed information, write for Catalog No. 109. For Needle Bearings to be used in heavier service, ask our associate, Bantam Bearings Corp., South Bend, Ind., for a copy of Booklet 103X.

THE TORRINGTON COMPANY, TORRINGTON, CONN., U. S. A. · ESTABLISHED 1866

Makers of Needle and Ball Bearings

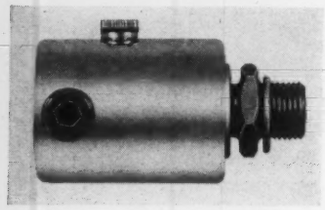
New York Boston Philadelphia Detroit Cleveland Chicago London, England

TORRINGTON NEEDLE BEARING

New PARTS AND MATERIALS

New Seal Handles Air, Oil

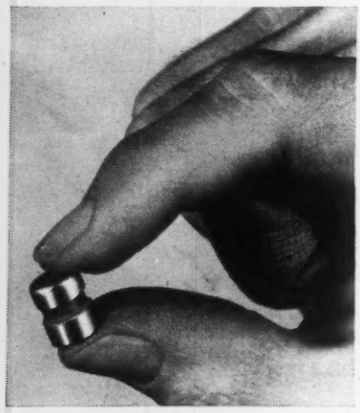
TO PERMIT air or oil to be introduced under pressure to rotating shafts, the Rotoseal is announced by Fawick-General Co., Akron, O. A positive seal, it can also be used for vacuum applications and can be run continuously in either direction, or can be reversed as often as necessary. Rotoseal originally was developed for use in conjunction with the company's Airflex clutch and has been thoroughly tested for many other applications. Three sizes are available: Size A has a ¼-inch straight-through opening, size B a ⅜-inch opening and size C a ⅝-inch opening. Rotoseal consists primarily of a short tubular spindle that rotates in a sealed double-row bearing, sealing being accomplished by a nonmetallic bushing running against spindle face. Sealing surfaces are ground and lapped and so constructed that the pressures are balanced to reduce bearing load variations under fluctuating pressure conditions. A felt seal is provided to prevent dirt from entering.



Rotoseal consists of a spindle rotating in a sealed double-row bearing, with a nonmetallic bushing running against the spindle face

Low-Price Mercury Switch Announced

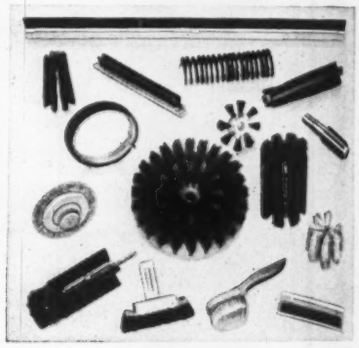
CALLED the "Tipit" switch, a low-price all-metal mercury switch is announced by Durakool Inc., 1010 North Main street, Elkhart, Ind. The "Tiny Tipit" illustrated has a capacity of ½-ampere at 24 volts to 4 amperes at 6 volts. It finds many applications where infrequent operation of a low-watt circuit is desired, and where high cost formerly prohibited the use of mercury switches. It can be used in exposive atmospheres. The Tipit switch mounts in a small holder with screw stakes for terminal connection. This assembly is attached to a movable member, the motion of which actuates the switch. Tipit operates on a tilt of 20 degrees or more.



Mercury switch meets needs where infrequent operation of a low-watt circuit is desired

Brushes Are Flexible, Replaceable

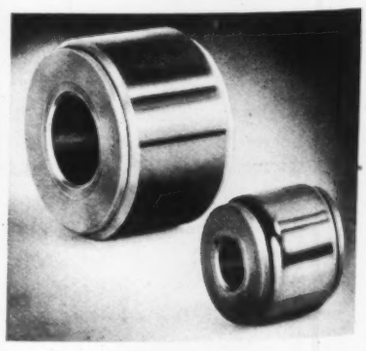
INTERCHANGEABLE and replaceable industrial brushes, embodying the "Steelgript" method of construction, are announced by the Fuller Brush Co., Industrial division, department 8C, Hartford, Conn. Strong, rigid metal backs under high pressure are folded and clamped over the base of the brush material to secure an extremely secure bristle setting. The brush material is set in a continuous strip. These strips slide into suitable grooves in a permanent metal core, and may be removed and changed. A feature of Steelgript construction is its flexibility, permitting brushes to be shaped and adapted to virtually every sort of machine application, including cylindrical, spiral, circular, flat, and curved.



Strips of brush material with metal backing slide into suitable grooves in permanent metal core

Needle Bearings Announced

PROVIDED with inner races and permanently attached end washers, new needle bearing assemblies are announced by the Torrington Co., Torrington, Conn. They are made in two series, designated the AR series for normal service and the AT series for

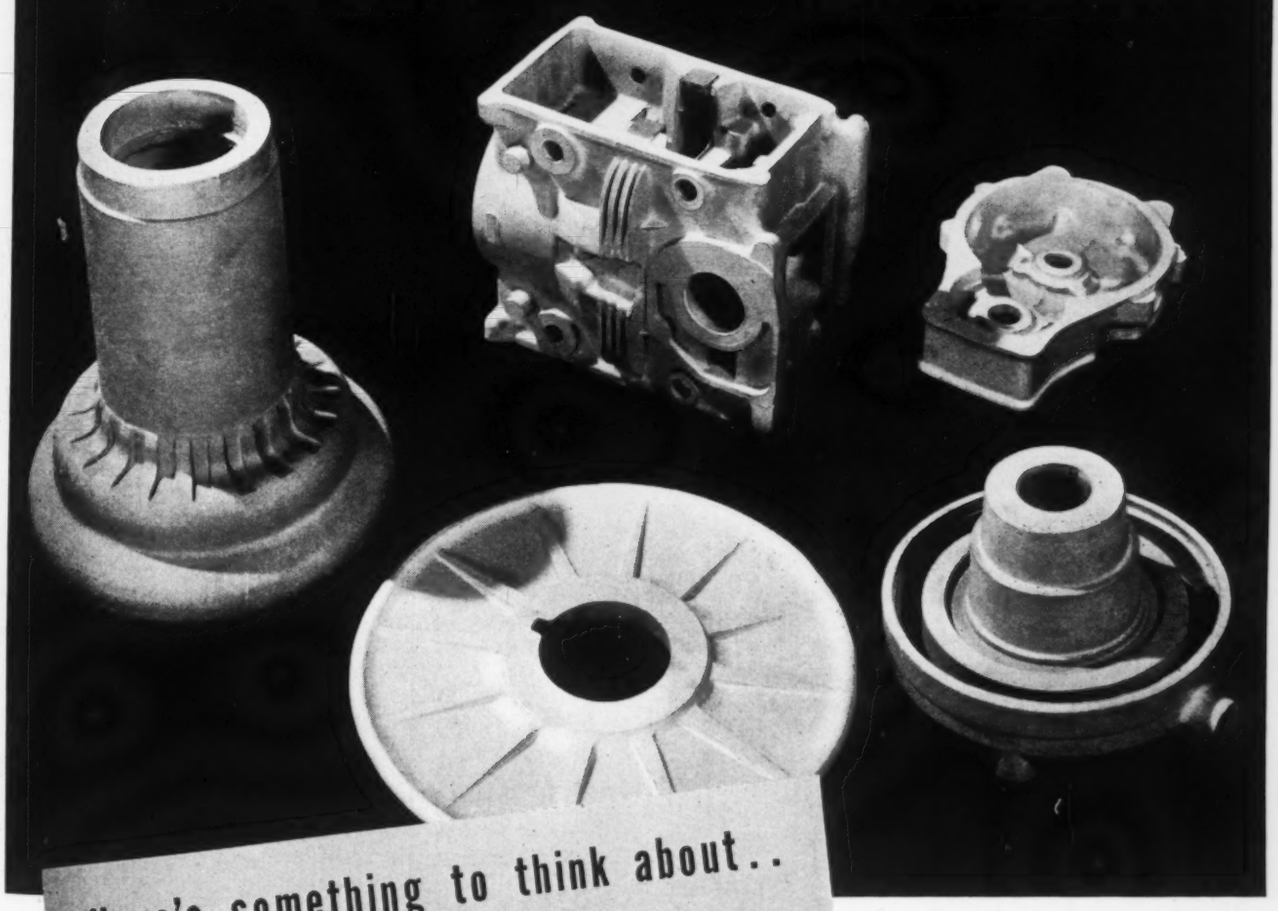


Inner races and permanently attached end washers are provided in needle bearing assemblies

MAZLO

MAGNESIUM ALLOYS

THE LAST WORD IN LIGHTNESS



Here's something to think about..

Where quantities are large enough to justify the mold costs, consider making your sand-cast Magnesium Alloy parts as permanent mold or semi-permanent mold castings. Production is faster. Cost-per-piece for the castings is generally less. You also save on rough weight and on many machining operations.

MAZLO Magnesium permanent mold castings have a fine, dense grain structure. Parts can be held to closer dimensional tolerances: frequently, less finishing is required.

Permanent mold castings are but one of the many ways in which to use MAZLO Magnesium Alloys to help improve your products. Their range of properties enables you to go *very* light most economically. Sales agent for MAZLO Magnesium products: Aluminum Company of America, 1703 Gulf Building, Pittsburgh, Pennsylvania.

MAZLO

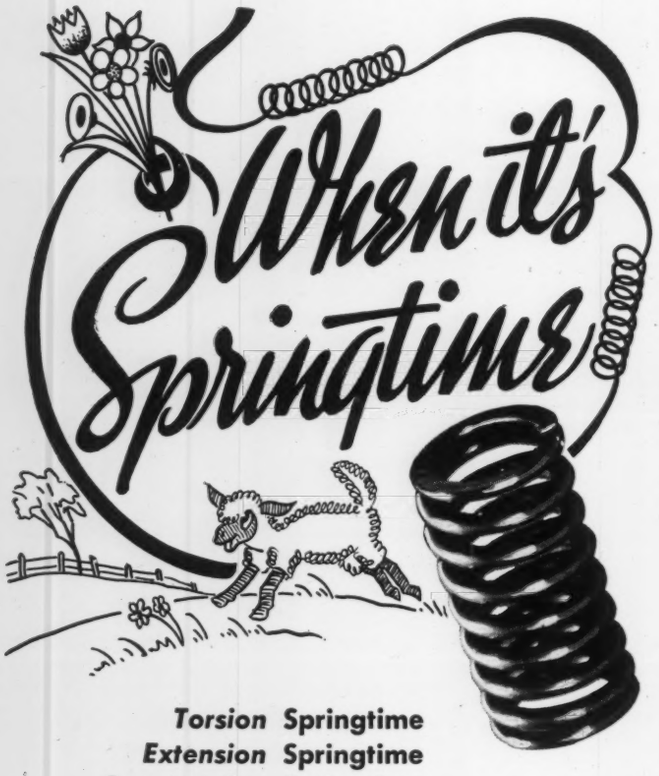
REG. U.S. PAT. OFF.

AMERICAN MAGNESIUM CORPORATION

DEFENSE COMES FIRST

To meet the needs of National Defense, the American Magnesium Corporation, now a wholly owned subsidiary of Aluminum Company of America, is increasing its manufacturing facilities at a rate many times that required by normal peace-time markets. When the emergency is past there will be an abundance of the fabricated forms of magnesium alloys available for industrial uses.

Meanwhile, magnesium is helping to meet the national emergency.



***Torsion* Springtime**
***Extension* Springtime**
***Compression* Springtime**

WHEN the time comes for you to buy springs, give thought to the quality and service you can get from Accurate. Whether the spring you need is the tiniest hair-like coil or a stout steel brute for slam-bang service, you'll find that Accurate controls and checks quality to the "nth" degree. Accurate builds dependability into its products to help you build it into yours. Accurate takes more than ordinary measures to meet delivery dates to help you meet yours. This care is building business for Accurate. It will help do the same for you. Let Accurate meet your next spring requirements — write today.

THIS advertisement first appeared in May 1940. Because Accurate's message to spring users is still the same, it is reprinted here in this Springtime of 1941.

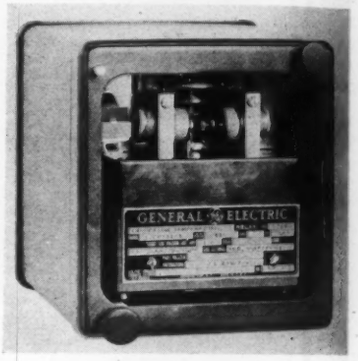
Accurate Springs

ACCURATE SPRING MANUFACTURING CO.
3813 W. LAKE ST. • CHICAGO, ILL.

heavy duty, and are particularly suitable for aircraft applications. All exposed surfaces are cadmium plated.

Temperature Relay Improved

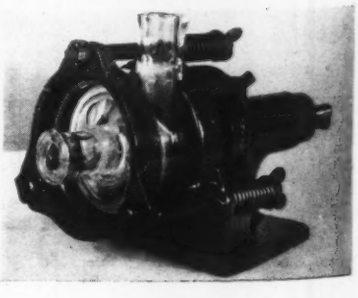
AN IMPROVED temperature relay designated Type CFT for protection of machines and transformers against overloading is announced by General Electric Co., Schenectady. It embodies the induction-cylinder design and supersedes the Type ICT induction-disk relay. The relay serves as the galvanometer in a Wheatstone bridge circuit comprising a resistance temperature detector in one arm and tapped bridge resistors in the other three arms. Since normal operating region of the relay is close to the pickup point, the high torque characteristic of the induction-cylinder feature provides more dependable and more consistent protection. The relay is adjusted to close its low-temperature contact at 80 degrees Cent. and its high-temperature contact at 95 Cent., with a 30-degree ambient. The balance point is midway between, as determined by the tap used on each of the three tapped bridge resistors, but other taps permit adjustments so that the balance point can be made higher or lower and still keep range between the closing of the contacts.



Overload protection is provided by thermal relay in combination across-the-line starter and disconnect switch

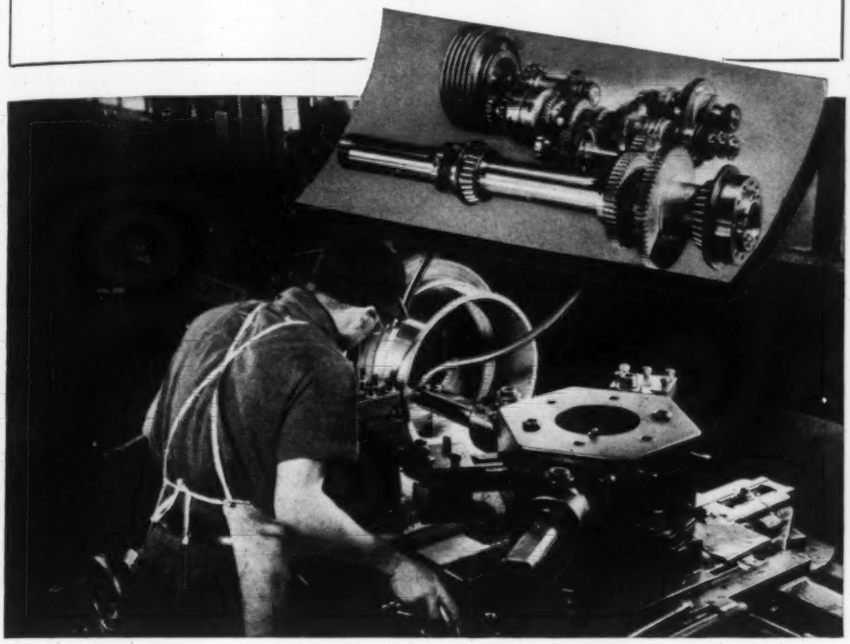
Glass Pump Made Smaller

SUCCESS of its glass centrifugal pump introduced last year has led Nash Engineering Co., South Norwalk, Conn., to bring out a smaller size, ¾ by 1-inch, with a capacity of 10 gallons per minute. Like the large pump, the new size actually utilizes glass for the volute, head and rotating impeller, and is fully transparent. It has many advantages where corrosive liquids or liquids which must be kept chemically uncontaminated are to be handled. A unique mechanical seal replaces the conventional stuffing box, and a safety unloading device eliminates possibility of fracture of

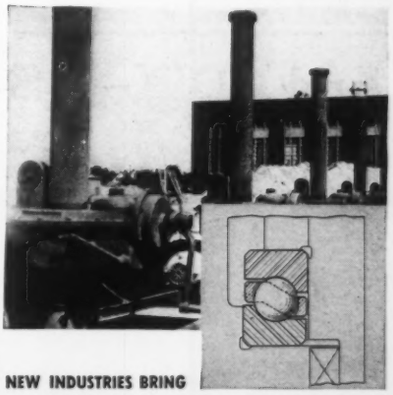


Volute, head and rotating impeller of smaller size pump are made of glass

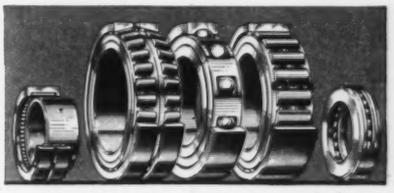
In the News
WITH BANTAM BEARINGS



FAST, ACCURATE PRODUCTION, always essential in machine tools, is more important than ever today. Turret lathes built by Gisholt Machine Company are designed throughout to meet these requirements—and Gisholt employs Bantam Ultra-Precision Tapered Roller Bearings on the spindle of many of its High Production Lathes to maintain the high degree of accuracy necessary in turret lathes. This is an outstanding example of Bantam service to machine tool builders and users.

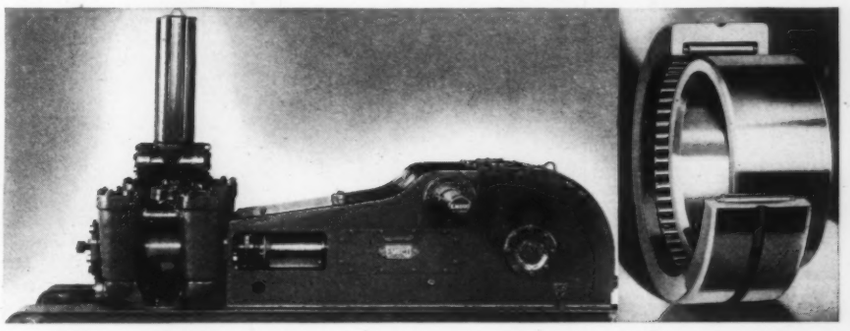


NEW INDUSTRIES BRING NEW PROBLEMS, and Bantam engineers are contributing their skill to the field of sewage treatment. For sluice gates like those shown here, built by The Filer & Stowell Co., Bantam designed special angular contact bearings that take thrust load from both directions, and radial loads also.



EVERY MAJOR TYPE OF ANTI-FRICTION BEARING is included in Bantam's line—straight roller, tapered roller, needle, and ball. Bantam engineers, with their broad background of experience in bearing design and application, can recommend the type that best suits *your* needs—or can design special bearings to meet special conditions. If you have difficult bearing problems, TURN TO BANTAM.

THIS GIANT ROLLER THRUST BEARING, 47½" O.D. by 5" thick, incorporates a split race engineered by Bantam to facilitate accurate positioning in assembly. Bearing was used by S. Morgan Smith Company to support a load of 456,000 pounds in assembling turbine equipment at Bonneville Dam—a typical instance of Bantam's skill in designing special bearings to meet unusual requirements.



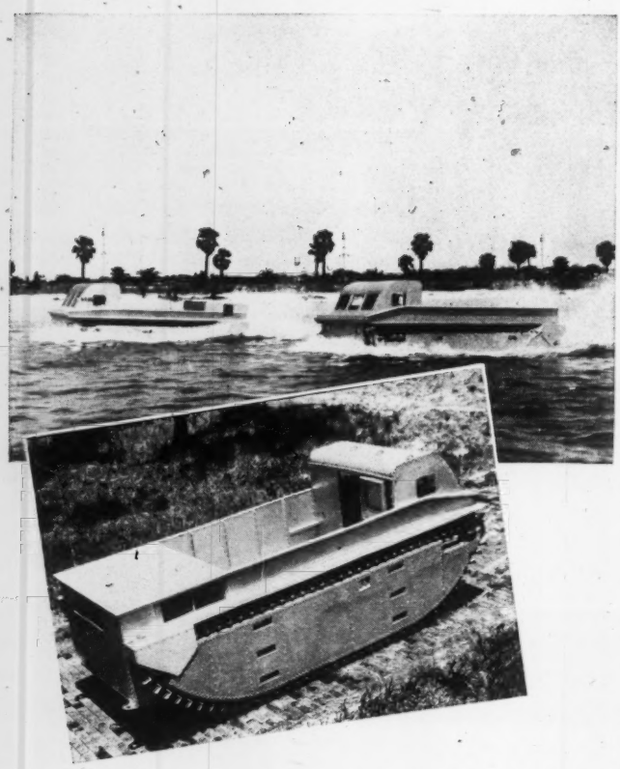
LIGHT WEIGHT AND HIGH EFFICIENCY are outstanding advantages of the slush pumps built by Emsco Derrick & Equipment Company. Bantam Quill Bearings, used on the crosshead, contribute to weight reductions through their compact design—to increased efficiency through their low coefficient of friction and little need of service attention, resulting in savings in operating costs. For further information on this unusual bearing, write for Bulletin No. B-104.

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

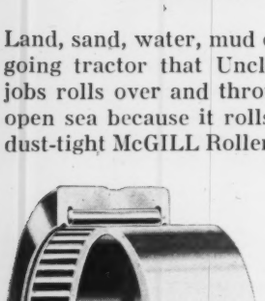
And NOW—a Sea-Going Tractor . . .



Amphibian Rolls Through "Hell-and-High-Water" on . . .

McGILL BEARINGS

Land, sand, water, mud or muck . . . "The Alligator" sea-going tractor that Uncle Sam has specified for HARD jobs rolls over and through everything from swamps to open sea because it rolls ON dirt-proof, water-tight and dust-tight McGILL Roller Bearings. Designed by McGILL for the Amphibian — only one of many McGILL applications.



The New Solidend *MULTIROL* Bearing

A combination of bearing demands, conservatively termed "unusual," is the normal schedule for the many McGILL Completely-Sealed Roller Bearings in "The Alligator."

What are your bearing requirements . . . McGILL has, or will make, the proper bearing for the task involved. Ask for complete details — ask us to prove it to you.

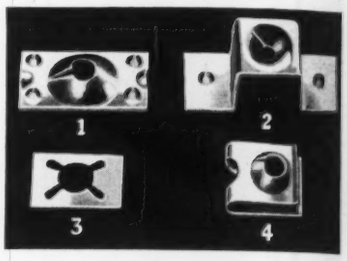
BEARING DIVISION

MANUFACTURING CO.
1450 North Lafayette Street
VALPARAISO, INDIANA

the glass. This pump handles hot acids or brine-cooled liquids with equal facility.

Fasteners Have Slit Thread

SPEEDIER production and more rigid assemblies in application are claimed for the line of Prestole fastening devices announced by Central Screw Co., Dept. 56, 3533 Shields avenue, Chicago. Formed by press operations in cold-rolled steel, the Prestole devices (see 1, 2 and 4 in illustration) embody a resilient conically formed and scientifically slit thread, threaded to match the screw. The Prestole method is offered in

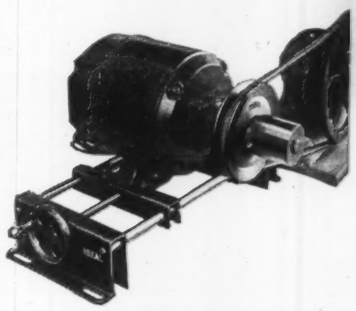


Fastenings are designed to save time and material, as well as provide rigid assemblies

stampings of standard patterns and special shapes to meet requirements. Another device called the Quickie (see 3) is a spring steel, push-on type of fastener, provided for one-time assembly. Both devices are designed to serve as lock fastenings as well as to save time and material on assembly lines.

Variable Pulley Mounts on Shaft

VARIABLE speed pulley announced by the Ideal Commutator Dresser Co., 1059 Park avenue, Sycamore, Ill., is designed for light, inexpensive machines, the pulley mounting directly on the motor shaft and requiring only standard V-belts. Features include short overhang, forced lubrication, balanced sheave and all-metal construction. Both halves of the sheave move, giving accurate belt alignment at all times. Pulley faces are curved so that the belt has full con-



Movement of base increases or decreases belt tension in variable speed pitch diameter

tact at all pitch diameters. Speed ratios up to 2¾ to 1 are available, and in sizes ranging up to ¾ horsepower. Complete unit includes variable pitch pulley and adjustable sliding motor base, movement of which backward and forward caused an increase or decrease in belt tension.

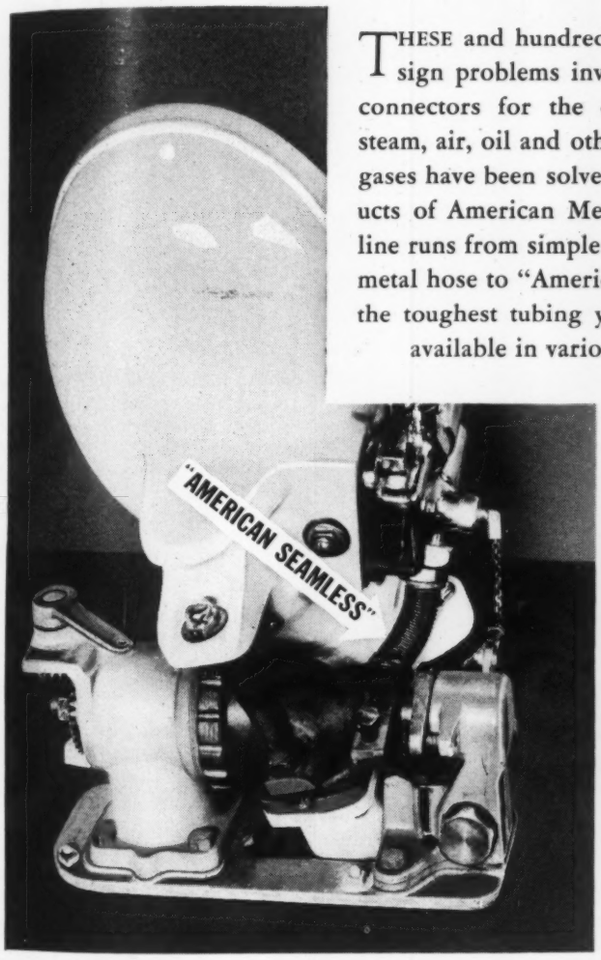
Caps Give Fuse Protection

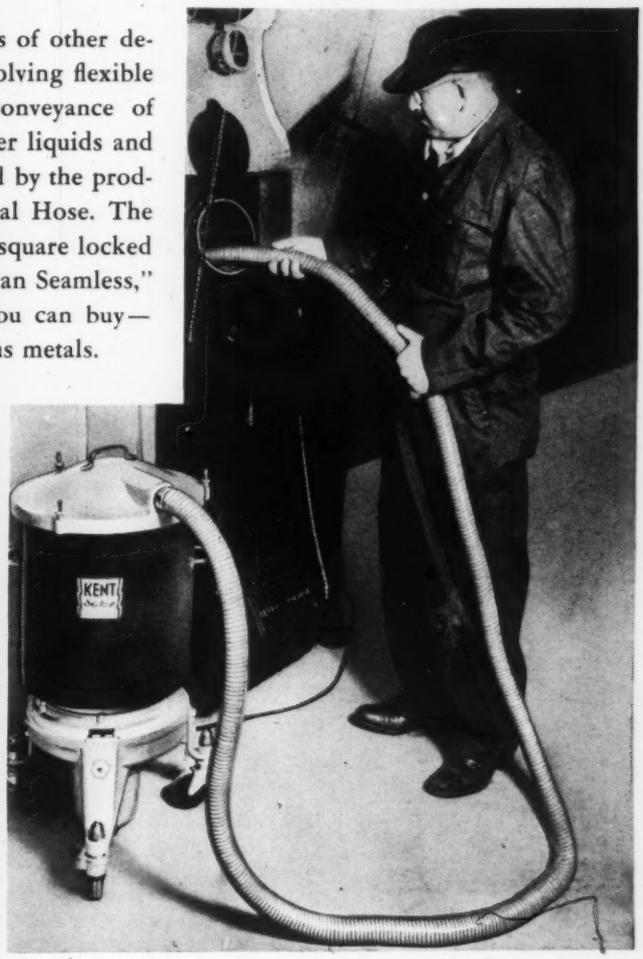
PROVIDING fuse protection to the exact capacity of the machine, independent of the line fuse, three-wire "Twist-Lock" fusible caps are announced by Harvey Hubbell Inc., Bridgeport, Conn. Small motors

Flexible Metal Hose

meets the challenge of countless connector problems

THESE and hundreds of other design problems involving flexible connectors for the conveyance of steam, air, oil and other liquids and gases have been solved by the products of American Metal Hose. The line runs from simple square locked metal hose to "American Seamless," the toughest tubing you can buy—available in various metals.





• Pullman engineers designing a closet for the newest type of Pullman car had to deal with the problem of getting it into the smallest possible space. Use of American Seamless unbraided bronze tubing for the water supply line enabled them to place the unit on a hinged arrangement so that when the closet door is closed the unit folds up out of the way. Other outstanding benefits realized from this type of flexible connection were provision for slight misalignment between parts in assembling the unit, tightness against low-pressure water, provision for vibration and, most important, allowance for complete flexibility of the entire unit.

• You can see at a glance how flexible metal hose blends right in with the trim lines of the Kent Double Suction Furnace and Boiler Cleaner, made by The Kent Co., Inc., Rome, N. Y. This all-steel vacuum hose stands grueling bombardment by scale, soot, dirt, metal chips and other abrasive substances encountered in furnace cleaning. The hose is especially designed to hold low vacuum and to allow a minimum of shrinkage under suction. Moreover, its lightness and flexibility make it easy to handle on the job. Small wonder practically every large builder of furnace cleaning equipment uses American Flexible Metal Hose. 41254

American Metal Hose

American Metal Hose Branch of THE AMERICAN BRASS COMPANY
General Offices: Waterbury, Connecticut
In Canada: ANACONDA AMERICAN BRASS LTD., New Toronto, Ont.
Subsidiary of Anaconda Copper Mining Company

Write for this new 24-page manual on American Seamless Flexible Metal Tubing. Contains more than 75 pictures and charts explaining applications and availability.

THE FIRST DRAWING I EVER MADE—GOOD AS NEW TODAY, THANKS TO ARKWRIGHT!

"Here's the first drawing I ever made on this job! Drew it twenty years ago on a piece of Arkwright Tracing Cloth. Just out of curiosity we ran it through the blue printer the other day, and the prints we got were as clean and 'snappy' as you'd get from a brand new tracing!"

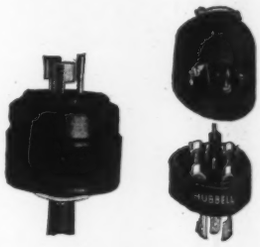
What this man did out of curiosity – you may *have* to do! Make sure now your important drawings can't be destroyed by tracing cloth that turns brittle and opaque with age. Specify Arkwright Tracing Cloths! You'll get a tracing cloth that is clean, highly transparent, free from imperfections, thin yet strong – with a surface the way you like it. You'll find one of the four Arkwright brands is just right for you! Arkwright Finishing Co., Providence, R. I.

Be sure to get your copy of our new catalog – free on request!

Arkwright

TRACING CLOTHS

also may be protected from overload with this device. Body is made of special impact-resisting plastic,

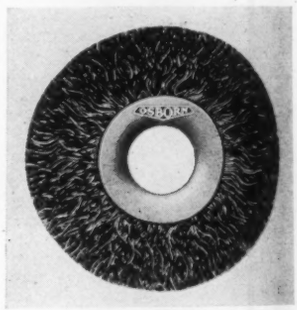


Machines and small motors are given independent protection by fusible caps

and exposed metal parts are cadmium plated to resist corrosion. Capacity is 1 to 15 amperes, 250 volts.

Wheel Brushes Power-Driven

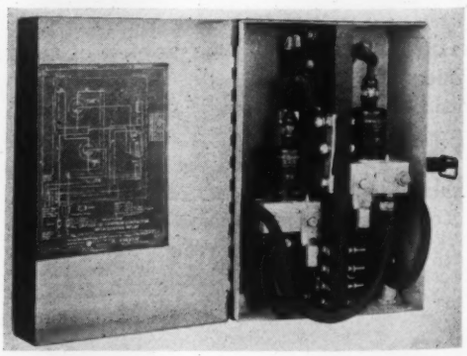
RINGLOCK method of construction is used in power-driven wheel brushes announced by the Brush division of the Osborn Mfg. Co., Cleveland. Brush material is securely locked in by means of a one-piece ring and a sleeve, the design providing a denser brushing surface and reducing breakage of the material to a minimum. With this construction wire wheel brushes are made in diameters from 1 to 12 inches.



One-piece ring and a sleeve securely lock material in wheel brush

Clamp Cools Ignitron Tube

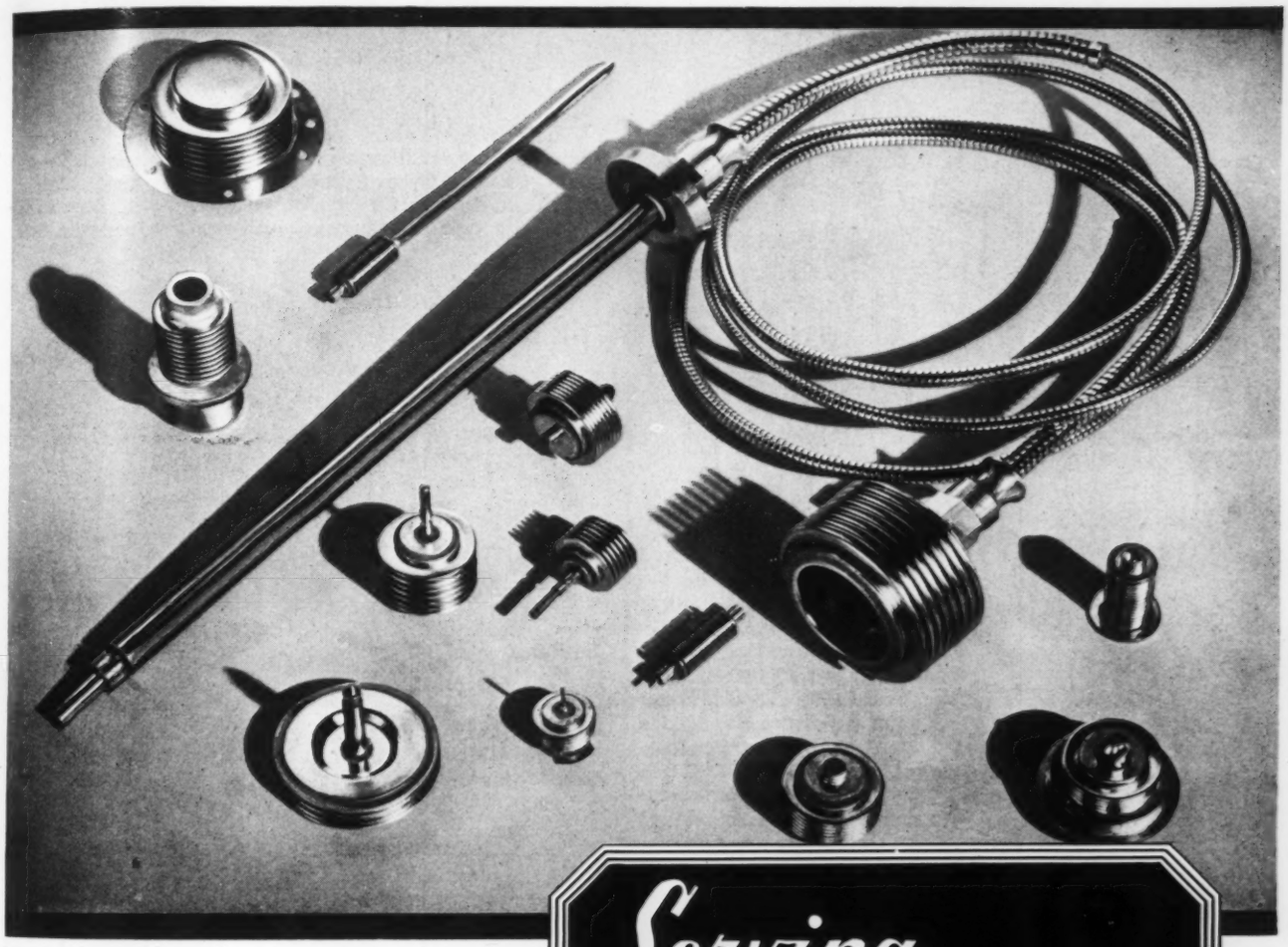
DEPENDING for its cooling on a special clamp into which it is fitted, an ignitron tube, Type GL-415, for resistance-welder control, is announced by General Electric Co., Schenectady. Consisting of a brass block with water passages, the clamp not only serves as a cooling medium but also as the cathode connection. Since there are no water connections to the tube itself,



Cooling clamp of ignitron tube consists of brass block with water passages

(*Continued on Page* 68)

HYDRON
METALLIC BELLOWS



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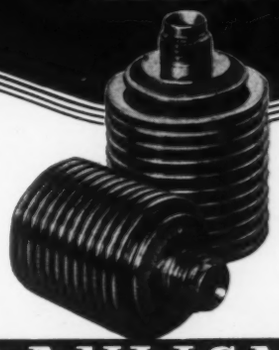
THE HEATING, VENTILATING, AND AIR-CONDITIONING INDUSTRY

We manufacture bellows and bellows assemblies ready for installation in steam traps, relief valves, temperature regulators, pressure regulators, air valves, and all other automatic temperature and pressure controls.

Complete engineering service.



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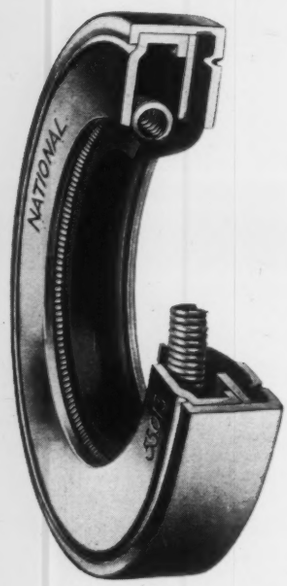


The reason engineers acclaim National Seals as today's solution to tomorrow's sealing problems is because of the superiority of Nationalized leather sealing members. Through National's special "duraflex" treatment, these firm, flexive and durable barriers against leakage not only provide positive and lasting protection for shafts and bearings—they add extra years of performance life to machinery—and at no extra cost.

NATIONAL MOTOR BEARING CO., INC.
1110 78th Avenue, OAKLAND, California
Branch Offices: 477 Selden Ave., DETROIT
2236 South Wabash Avenue, CHICAGO
122 E. 42nd St., N. Y. • 401 N. Broad St., PHILADELPHIA. Before you specify seals for machines you build or buy, investigate National Seals. Write for Bulletin 44 today.

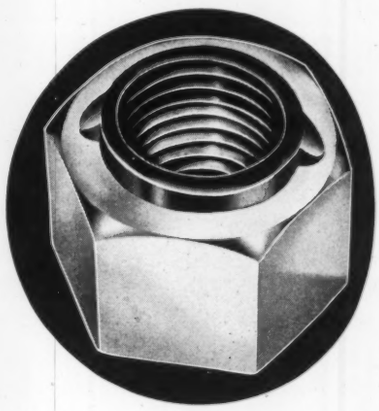
NATIONALIZED LEATHER MAKES THE DIFFERENCE
Nationalized Leather sealing members contain no wax or other unstable ingredients. They will not become soft or flabby. They will not creep nor turn. They are tougher than Nature's own product.

OF INTEREST TO DESIGNING ENGINEERS
Before you specify or buy any seal, you should have the details on National Seals. Write for your copy of Catalog 44 today.

removal and replacement is easy. Formerly a built-in water jacket was used. Ability to pass high-peak currents makes these ignitron tubes particularly suitable for controlling the current of resistance welding machines. A pair of tubes is capable of controlling 265 kilovolt-amperes of resistance welding load on a 5½ per cent duty cycle.

Nuts Resist Vibration

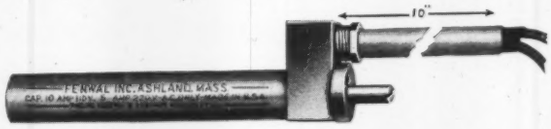
ALL-METAL nuts announced by Security Metal Products Inc., Kalamazoo, Mich., have an elliptical-shaped spring steel retainer permanently seated in the head. Permanent pressure is created by this retainer so that only a wrench can loosen the nut. If necessary, these nuts can be removed and replaced on the bolt many times without damaging or distorting threads. Vibration will not loosen them and it is said they remain perfectly tight even if the bolt elongates or bolted parts become worn and loose.



Permanent pressure is created by steel retainer in all-metal nut

Thermoswitch Is Waterproof

A WATERPROOF and vaporproof submersion thermoswitch is announced by Fenwal Inc., Ashland, Mass. The thermo-responsive element is like that in other Fenwal thermoswitches, but has a hermetic seal for the adjusting screw and a watertight conduit for the leads. The switch can be hung into a vessel containing a fluid by bending the conduit to serve as a hook which carries the leads over the edge of the vessel. It can be suspended in a closed tank by fitting a packing gland to the cover.



Conduit of submersion thermoswitch can be bent to serve as hook over edge of vessel

Switch Operates on Low Voltage

AN EXTREMELY small mercury switch measuring only 7/16-inch long by ⅜-inch diameter has been announced by Littelfuse Inc., 4748 North Ravenswood avenue, Chicago. It is designed for use in low voltage circuits up to 25 volts alternating or direct current, and currents up to 10 amperes at 6 volts and 3 amperes at 25 volts. There is no friction or wear in operation

WHAT WOULD YOU DO IN A CASE LIKE THIS?

Here's the Problem. A pump had to be taken down daily and cleaned thoroughly. For easy cleaning, the entire assembly was held together by bolts. But sufficient tightening of the bolts to seal the assembly exerted so much pressure on the packing that it forced the heel of the packing tightly against the ram—and the sealing lip against the bottom of the stuffing box. Thus packing life as well as sealing efficiency was unsatisfactory.

How G & K Packing Engineers Improved Operation and Lengthened Packing Life

1. Replaced the hard gasket used to seal the cap. In its place—a Spartan washer that would seal without excessive tightening of the assembly.

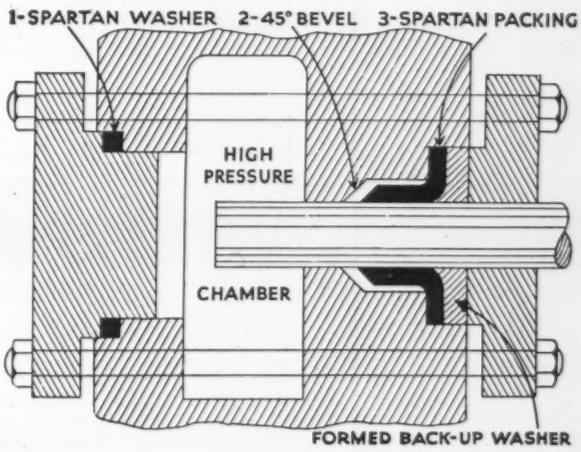
RESULT: eliminated crushing of flange packing.

2. Machined the bottom of the stuffing box to a 45° angle.

RESULT: pressure medium allowed to get behind the packing, forcing it against the shaft.

3. Replaced previous packing with a Spartan Packing —made from G & K's own high-tensile-strength packing leather, abrasion- and heat-resisting.

RESULT: despite daily cleaning and reassembling of machine, packing can be used over and over again.



CALL ON G&K AT THE "PACKING POINT"

Have Graton & Knight packing engineers answer your packing problems. They will help you determine the design of packing and type of leather and treatment that will serve your operating conditions best.

PUT IN SPARTAN AT THE "PACKING POINT"

Spartan leather has been proved the top-quality leather in the packings industry. Whether for delicate or heavy duty service, Spartan will give longest life. It has highest abrasion and heat resistance, is not affected by oil, water, or other commonly used pressure mediums, and will not dry out hard and brittle.

Spartan Packings

GRATON & KNIGHT CO.

WORCESTER GRATON AND KNIGHT **MASSACHUSETTS**

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FOR BETTER MACHINES AND APPLIANCES

Direct to You!

A New Policy . . . a Distinctive Idea . . . by the outstanding pioneer of Lubricant-Retaining Bearings (Established 1883).

The New Policy?—Hundreds of standard sizes of "Compo" Oil-Retaining Porous Bronze Bearings in STOCK, ready for Immediate Shipment . . . HERETOFORE MADE ONLY TO ORDER!

The Distinctive Idea?—SHIPMENTS DIRECT FROM THE FACTORY TO YOU. No Intermediates—No Delay! No Confusion—AND THE GREATEST ECONOMY!

The New "Compo" Stock List No. 1 (illustrated above) FREE FOR THE ASKING. A quick-reference tabulation of hundreds of STOCK sizes—plain, flanged and thrust—with prices . . . and simplified charts on Permissible Loads, Shaft Clearances and Installation (without machining) in handy form to fit your letter file.

WRITE FOR YOUR COPY, NOW
Save Time, Expense and Costly Delays

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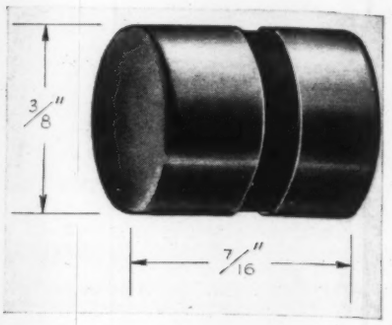
BOUND BROOK OIL-LESS BEARING CO.
(Est. 1883) Main Office and Plant: BOUND BROOK, NEW JERSEY
Sales and Service: DETROIT, MICHIGAN and LOS ANGELES, CAL.

FOR BETTER MACHINES AND APPLIANCES

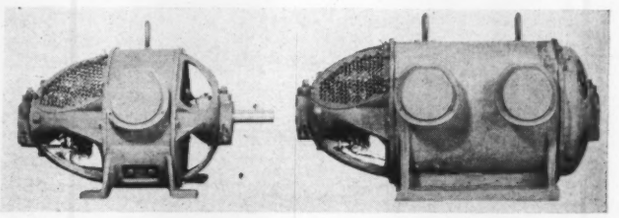
and no attention is required. A new baffle device assures positive "make and break" operation, with no opportunity for a flickering action when the machine is jolted.



Extremely small mercury switch operates at low voltages without friction or wear

Adjusts Speed Over Wide Range

FOR industrial applications requiring smoothly adjustable speeds over wide ranges with constant torque, a 10 to 1 adjustable speed drive is announced by Westinghouse Electric & Mfg. Co., East Pittsburgh. Using a series circuit without the usual exciter, the drive is employed where only alternating current is available. It comes in ratings from 1 to 15 horsepower with a standard speed range of from 175 to 1750 revolutions per minute, for 2 or 3-phase operation on 220, 440 and 550-volt, 60-cycle systems. The new drive has five parts. A single-unit motor-generator set, consisting of a squirrel cage induction motor driving a series direct current generator, supplies operating voltage for a direct current series motor coupled to the driven load. A rheostat in parallel with generator series field controls the driving motor speed. Control apparatus consists of an across-the-line starter for the squirrel-cage motor, and a pushbutton station.



Motor-generator set and direct current series motor are two primary parts of adjustable speed drive

Combination Control Announced

FOR use with squirrel cage and single-phase motors, a combination across-the-line starter and motor disconnect switch is announced by Cutler-Hammer Inc., Milwaukee. Front operation allows close ganging of a number of units in compact width and height multiples. Overload protection is provided by the C-H eutectic alloy thermal overload relay which permits working the motor up to maximum limit safely, yet provides positive protection. Overload heater coils and operating coils are readily interchangeable. Mechanical door interlock prevents opening the door when the disconnect switch is closed. The starter is available with either three or four poles, in five sizes, horsepower ratings from 6½ to 200 horsepower, and with several types of cover control. Watertight and dust-tight en-

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Manufacturers Rubber & Supply Co.
ALBANY, NEW YORK
Sager-Spuck Supply Co., Inc.
ALLENTOWN, PENNSYLVANIA
Wm. H. Taylor & Co., Inc.
ATLANTA, GEORGIA
J. M. Tull Metal & Supply Co.
BALTIMORE, MARYLAND
Carey Machinery & Supply Co.
BOSTON, MASSACHUSETTS
Boston Gear Works, Inc.
Chandler & Farquhar Co., Inc.
BRIDGEPORT, CONNECTICUT
Hawley Hardware Company
BROOKLYN, NEW YORK
H. L. Dickie
BUFFALO, NEW YORK
Root, Neal & Company
BURLINGTON, NORTH CAROLINA
Kester Machinery Co.
CANTON, OHIO
Manufacturers Rubber & Supply Co.
CHARLOTTE, NORTH CAROLINA
Mathews-Morse Sales Co.
CHICAGO, ILLINOIS
Berry Bearing Co.
Boston Gear Works, Inc.
Chicago Pulley & Shafting Co.
Power Transmission Equipment Co.
CINCINNATI, OHIO
The Queen City Supply Co.
CLEVELAND, OHIO
Boston Gear Works, Inc.
The Mau-Sherwood Supply Company
DALLAS, TEXAS
Geo. J. Fix Company
DAVENPORT, IOWA
Standard Bearings Company
DAYTON, OHIO
The Klinger-Dills Company
DENVER, COLORADO
Denver Equipment Company
The Western Belting & Packing Co.
DES MOINES, IOWA
Standard Bearings Company
DETROIT, MICHIGAN
The Chas. A. Strelinger Co.
EVANSVILLE, INDIANA
Berry Bearing Co. Inc.
HAMMOND, INDIANA
Berry Bearing Co. Inc.
HARTFORD, CONNECTICUT
Silliter-Holden, Inc.
HIGH POINT, NORTH CAROLINA
Kester Machinery Co.
INDIANAPOLIS, INDIANA
Indianapolis Belting & Supply Co.
Vonnegut Hardware Company
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The S. B. Hubbard Company
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NEW BRITAIN, CONNECTICUT
Smith & Klebes, Inc.
NEW HAVEN, CONNECTICUT
The C. S. Mersick Company
NEW ORLEANS, LOUISIANA
R. J. Tricon Company
NEW YORK, NEW YORK
Morris Abrams, Inc.
L. C. Biglow & Co., Inc.
Boston Gear Works, Inc.
Bronx Hardware & Supply Co. Inc. (Bronx)
OAKLAND, CALIFORNIA
C. W. Marwedel
PEORIA, ILLINOIS
Berry Bearing Company
PHILADELPHIA, PENNSYLVANIA
Boston Gear Works, Inc.
Maddock & Company
PITTSBURGH, PENNSYLVANIA
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YOU can buy Boston Gears from any one of the above direct factory branches or authorized distributors. Large stocks of Boston Gears are maintained in these various cities to give you the best gear service possible. Select your gears from the specifications shown in our Catalog No. 53 — over 2,000 different, completely finished gears available from stock. Simply order by catalog number from your nearest factory branch or distributor. Write today for your free copy of our General Catalog No. 53. BOSTON GEAR WORKS, Inc., North Quincy, Massachusetts.

Here are some of the gears carried in stock by Sager-Spuck Supply Co., Inc., our distributor in Albany, New York.

Write to any of the above for your Free Copy of Catalog No. 53 on Boston Gears.

Please send me a copy of Boston Gear Catalog No. 53 giving complete specifications on all Boston Gears available from stock.

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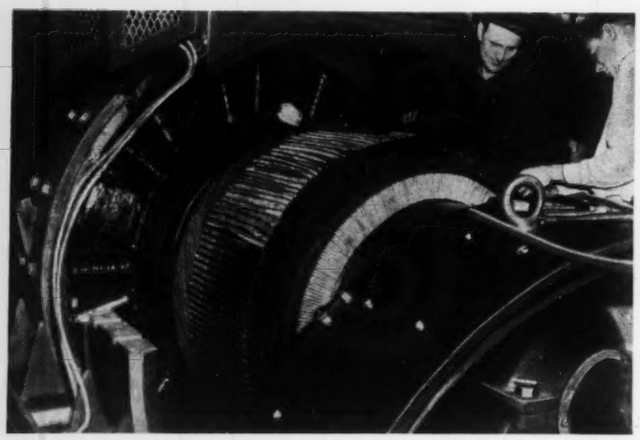


"IRVINGTON" Varnished Fiberglas has proved its superiority in many motor installations such as this.

"IRVINGTON" VARNISHED FIBERGLAS

Better Insulation More Easily Applied

"IRVINGTON" Varnished Fiberglas makes powerful motors smaller and lighter and tiny instruments more efficient and long-lived. It allows hundreds of types of electrical equipment to operate more efficiently, for more years, at higher temperatures, with greater resistance to attacking elements.

"IRVINGTON" Varnished Fiberglas is properly impregnated and coated with insulating varnish of highest grade to withstand the severe abuse which Fiberglas permits.

Here is glass cloth, woven from continuous fibers as manufactured by Owens-Corning Fiberglas Corporation; then thoroughly impregnated and coated by Irvington with high heat resisting black or clear insulating varnishes developed especially for this purpose.

To secure the benefits of highest insulation resistance, resistance to impact and abrasion, and the best balance in overall mechanical, electrical and chemical characteristics, the Fiberglas you use should be factory impregnated by Irvington's modern methods and with "IRVINGTON" High Heat Resisting Insulating Varnishes.

This superior product comes to you all ready to go in place, eliminating costly, time-consuming varnish impregnation and coating operations in your plant.

Detailed technical data and specifications for standard "IRVINGTON" Varnished Fiberglas cloths and tapes are yours for the asking. Write dept. 86. Data will gladly be furnished on the development and production of special combinations of Fiberglas cloth and varnish.

STANDARD OF THE WORLD
IRVINGTON INSULATION
TRADE MARK

IRVINGTON VARNISH & INSULATOR CO.

IRVINGTON, NEW JERSEY, U. S. A.

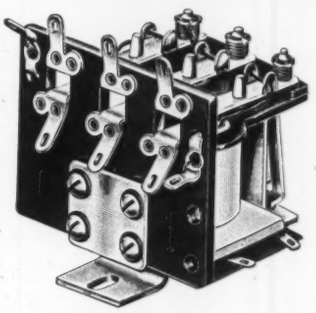
PLANTS AT IRVINGTON, N. J. and HAMILTON, ONT., CAN.

Representatives in 20 Principal Cities

closures are available, as well as those for hazardous locations.

Add Three-Pole Relay to Line

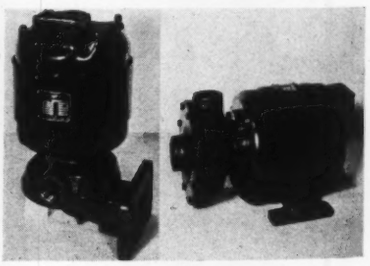
ADDITION of a 3-pole relay to its line of Type G relays is announced by G-M Laboratories Inc., Chicago. One feature of these relays is the self-cleaning wiping action of the contacts each time they are closed. Dust particles and films of corrosion are thus displaced. Supplied for a large variety of operating voltages, either alternating or direct current, these relays are also available with any of a number of contact materials to suit particular jobs.



Dust particles and film corrosion are displaced by wiping action of contacts in relay

Announce Motor-Driven Pumps

TWO motor-driven centrifugal pumps for use where dirt or abrasives may be present in the liquid and where a large volume of flow is desired at low head, are announced by Brown & Sharpe Mfg. Co., Providence, R. I. Both are compact, No. 225 having a foot-type motor bracket with motor and pump unit closely coupled. The discharge port can be located at any 90-degree position with respect to the motor by shifting the pump assembly on the motor end bell. No. 245 has flange mounting integral with the pump so that no inlet piping is required. Its discharge port can be shifted to any 45-degree angle. These pumps are designed for operation with the impeller below the liquid level and can be mounted in practically any position except that the motor preferably should not be below the pump. The discharge is in a line radial from the center of the rotor assembly, permitting uniform piping and direct flow of liquid. A mechanical seal prevents leakage of liquid and motors are totally enclosed.



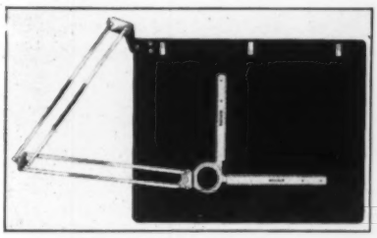
Centrifugal pumps are for use where large volume of flow is desired at low head

Engineering Dept. Equipment

Drawing Machines Are Portable

A LINE of portable drawing machines, taking paper sizes from 9 by 12 inches to 18 by 24 inches, is announced by the Drafto Co., 181 Walnut street,

Cochranton, Pa. All models are mounted on masonite board with parallel arms and protractor plate constructed of stainless steel. Two small size models, taking paper in sizes 9 by 12 and 10 by 15 inches,

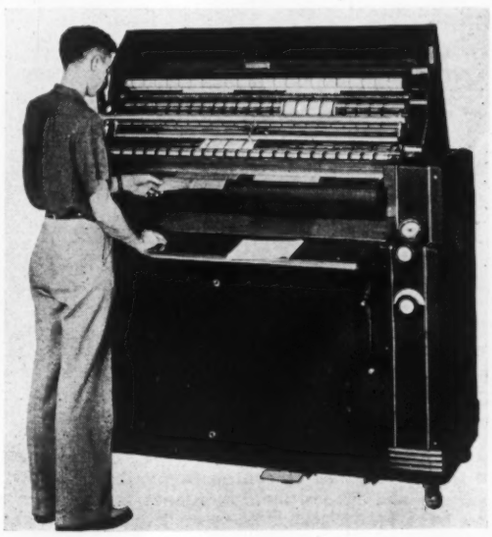


Small size models of portable drawing machine feature scales made in one piece

feature scales made in one piece, permanently attached to the protractor plate. Protractor for these models is graduated in 2 degrees, and the clamping device provides equal locking tension at all angles to prevent slippage.

Announce Developing Machine

KNOWN as the No. 159 Volumatic developer, a high speed developing machine is announced by Charles Bruning Co. Inc., 100 Reade street, New York. It is to be used with the Bruning Model 75 BW printer. In operation, sensitized paper and tracings are fed into the machine at the front, where they are immediately exposed in the printer section. A vacuum separator roll at the discharge point of the printer sepa-



Developing machine operates at high speed in conjunction with printer

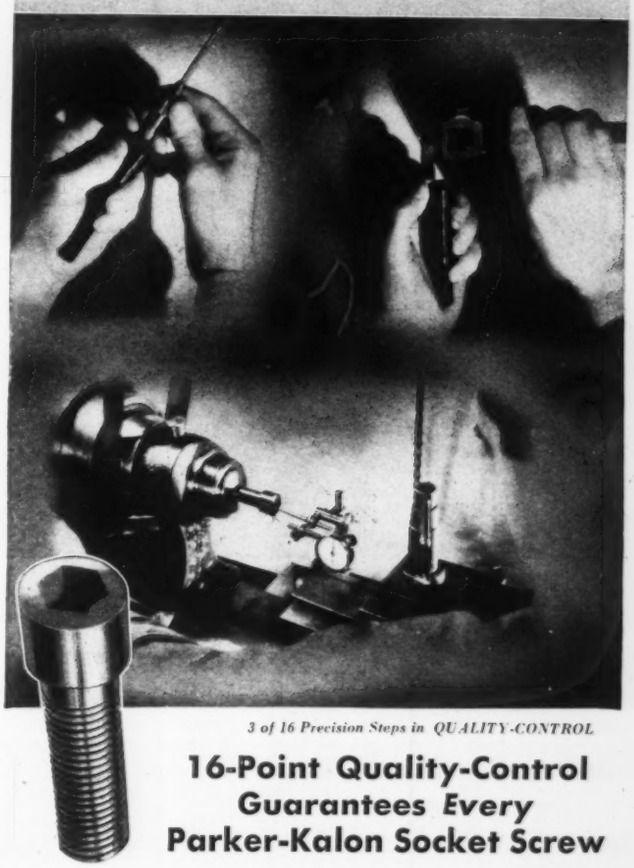
rates the tracings from the exposed prints, allowing the prints to pass automatically to the developing and drying sections. The tracing is returned to the operator, while the completely developed print is delivered flat and dry at the rear of the machine.

Meetings and Expositions

April 3-19—

Society of Industrial Designers. Chicago society will have an exhibition at Art Center, 820 North Michigan avenue, Chi-

"Doubtful" Socket Screws
"BLACKBALLED"!



3 of 16 Precision Steps in QUALITY-CONTROL

16-Point Quality-Control Guarantees Every Parker-Kalon Socket Screw

Most socket screws are good socket screws. But it takes only a few poor ones in a lot to cause trouble. That's why it pays to specify Parker-Kalon!

For Parker-Kalon gives you complete protection against "doubtful" screws—screws that *look* all right but of which a percentage fail in use—resulting in assembly delays and service complaints. In Parker-Kalon's QUALITY-CONTROL Laboratory—finest in the industry—an exacting 16-point inspection routine assures unvarying uniformity of physical and metallurgical characteristics . . . *eliminates "doubtful" screws.*

You can get this extra protection at no extra cost! Specify PARKER-KALON! Parker-Kalon Corporation, 192-200 Varick Street, New York.

Quality-Controlled

16-point test and inspection routine covers: Chemical Analysis; Tensile and Torsional Strength; Ductility; Shock Resistance under Tension and Shear; Hardness; Head diameter, height and concentricity; Socket shape, size, depth and centricality; Class 3 Fit Threads; Clean-starting Threads.

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Socket Screws

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Through selective processing of ABSCO Meehanite the combination of Density, Rigidity and Toughness essential for such requirements as Hydraulic Press parts is obtainable. ABSCO production standards assure adherence to the most exacting specifications.

WRITE FOR THE MEEHANITE WHEEL CHART

It provides full information about the Controlled Qualities which enable Meehanite to supply precisely the requirements needed for a wide variety of exacting work.

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cago. Additional information may be obtained from the Art Center.

April 7-11—

American Chemical Society. Semiannual meeting to be held in St. Louis. Charles L. Parsons, Mills building, Washington, is secretary.

April 16-19—

Electrochemical Society Inc. Meeting to be held at Hotel Cleveland, Cleveland. Colin G. Fink, 3000 Broadway, New York, is secretary.

April 23-25—

Petroleum Industry Electrical association. Annual meeting and exhibition to be held at Mayo hotel, Tulsa, Okla. J. F. Collerein, P. O. Box 2412, Houston, is secretary.

April 25-26—

Association of Manufacturers of Wood Working Machinery. Annual meeting to be held at the Palmer House, Chicago. Additional information may be obtained from the association headquarters, 111 West Washington street, Chicago.

April 28-May 2—

American Mining Congress. Annual convention and exposition to be held at Music Hall, Cincinnati. P. D. McMurrer, Munsey building, Washington, is assistant to secretary.

May 9-11—

Laundry and Cleaners Allied Trades association. Educational clinic and exhibition to be held at Grand Central Palace, New York. Rodger R. Jackson, 95 Liberty street, New York, is manager.

May 11-15—

National Electrical Manufacturers association. Spring conference to be held at Homestead hotel, Hot Springs. R. J. Blais, 155 East Forty-fourth street, New York, is convention manager.

May 12-13—

Society of Automotive Engineers. National production meeting to be held at Schroeder hotel, Milwaukee. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary.

May 12-15—

American Foundrymen's association. Forty-fifth annual convention to be held at Pennsylvania hotel, New York. N. F. Hindle, 222 West Adams street, Chicago, is assistant secretary.

May 19—

American Welding Society. West coast district meeting to be held in Los Angeles, in conjunction with the Western Metals Congress and Exposition. Additional information may be obtained from M. M. Kelly, 33 West Thirty-ninth street, New York, secretary.

May 19-21—

American Institute of Chemical Engineers. Semiannual meeting to be held at Edgewater Beach hotel, Chicago. Additional information may be obtained from S. L. Tyler, 50 East Forty-first street, New York, secretary.

May 26-27—

Stoker Manufacturers association. Annual meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Marc G. Bluth, 307 North Michigan avenue, Chicago, is secretary.

June 1-6—

Society of Automotive Engineers. Summer meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary.

The things that COUNT in many products are made by Veeder-Root

Veeder-Root Counting Devices give the true count of many a machine's production . . . its stops and starts. They also make absolutely accurate recordings of the number of pieces or the volume that a machine produces . . . eliminate short-runs and over-runs.

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IN CANADA: Veeder-Root of Canada, Ltd., Montreal

★

Acknowledgment

★

Machine Design takes this opportunity of thanking all those companies and individuals who contributed toward the preparation of the accompanying "Machine Drives and Controls" Supplement, stitched into the center of this April issue. We are particularly indebted to the manufacturers of machinery and to the producers of drives and control equipment for their co-operation and support in making this supplement possible.

★

Theory of Elasticity in Practical Design

(*Continued from Page* 40)

at the level 2. Note that this band persists with but little disturbance to about ¼ d from the load.

At the top and bottom $y_1 = \pm 1$ and Equation 58 reduces to

$$n = \frac{6M_x}{Hd^2} = .462M_x$$

Checking this value along the bottom from $2d$ away from the load to directly under the load shows a maximum error of only 3 per cent. In this case the error of the photoelastic work may be as high as 5 per cent. Along the top edge the error is negligible to within ½ d from the load where it reaches 5 per cent.

Check was also made by applying Equation 58 along the vertical section ½ d away from the load. Maximum error along this section was only 7 per cent of the maximum stress. Check at ½ d to the left of the right hand load (not shown in figure) showed an error of 5 per cent at the top and 1½ per cent at the bottom.

If $V_x = 0$, Equations 55, 56, and 57 reduce to Equation 35, the case for uniform bending previously developed.

If the beam is a simple cantilever carrying a single load P at its left end, $V_x = -P$ and $M_x = -Px$ and Equations 55, 56, and 57 reduce to Equations 38 and 39, previously developed.

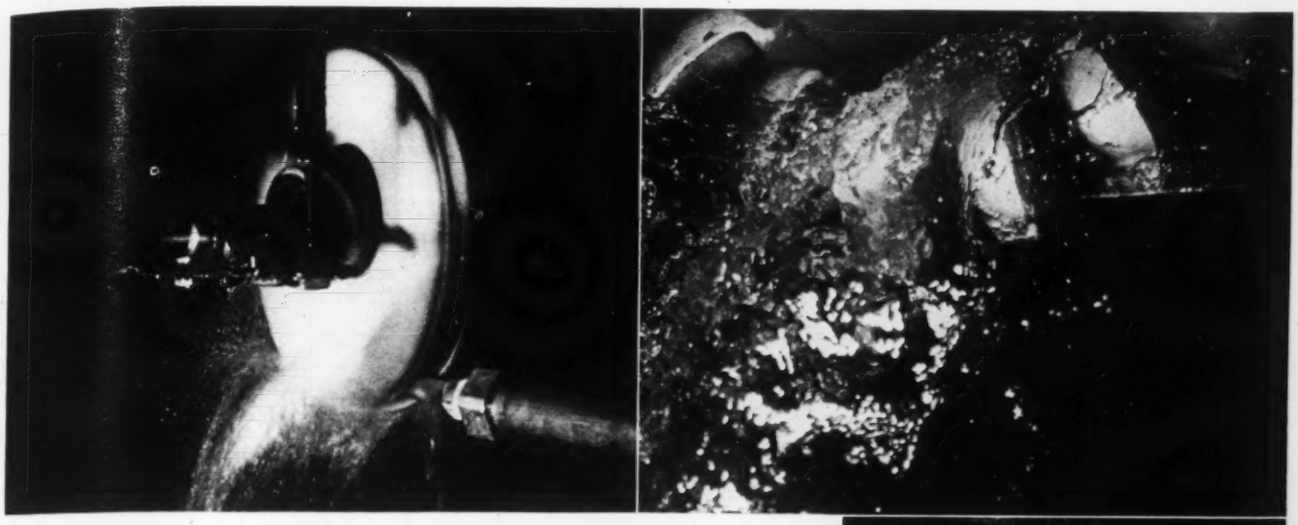
If it is a simple beam with a uniform load along its entire length, as illustrated in *Fig.* 22, the stresses away from the ends are given by Equations 52, 53, and 54. Note that these give at the ends, $x = 0$ and $x = l$,

$$S_x' = -\frac{q}{2}\left(y_1^2 - \frac{3}{5}\right) y_1$$

which would appear contradictory inasmuch as there is no horizontal load on the ends. However, the summation horizontally, and the summation of moments of these stresses is equal to zero, so that this system is "statically equivalent" to no load.

Elemental analysis is correct in this case only for the shear stress. S_y as given by Equation 53, and the correction given by S_x', must be added to the elemental system. The absolute values of these additions, which are constant throughout the length of the beam, are illustrated in *Fig.* 23.

S_x' is a maximum at the top and bottom of the beam, and S_y a maximum at the top. It is of interest to compare the value of these corrections relative to the maximum value of S_x as computed by elementary theory. This maximum value is at the center at the top and bottom faces and equals $\mp 3ql^2/4d^2$. Sub-



Stroboscopic F-L-A-S-H Pictures

THE MOTION of many mechanical phenomena which are not cyclic, repetitive or reciprocating can be studied most readily by means of single-flash stroboscopic photographs. Many persons have found the General Radio STROBOTAC and STROBOLUX, which are equipped to operate at single flashes, very useful for taking single-flash photographs when the area to be illuminated is relatively small.

The STROBOTAC-STROBOLUX when connected for single-flash operation provide a powerful flash of about 1/30,000th second duration. The intensity of this flash is high enough to take excellent single-flash pictures with the simplest camera equipment.

The photograph above at the left was taken with ordinary lighting. It represents a Pelton wheel in operation. At the right the same wheel was photographed with a single flash from the STROBOTAC-STROBOLUX. Note how effectively the water jet, the individual particles of water and the buckets on the Pelton wheel have been stopped.

When viewed visually, due to the non-uniform motion of the water drops, it is quite difficult to visualize the exact water column formation; with a single-flash picture the complete story is evident immediately.

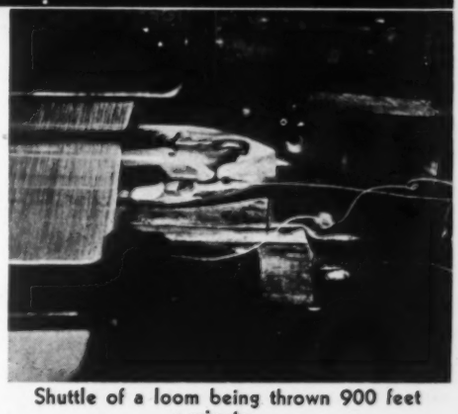
Single-flash photography with the General Radio STROBOTAC and STROBOLUX is really quite simple. Little practical photographic experience is required. The additional equipment needed is high-speed film, almost any type of camera and some simple means of synchronizing the flash with the shutter.

Let us tell you more about the interesting possibilities of stroboscopic photography in industry.

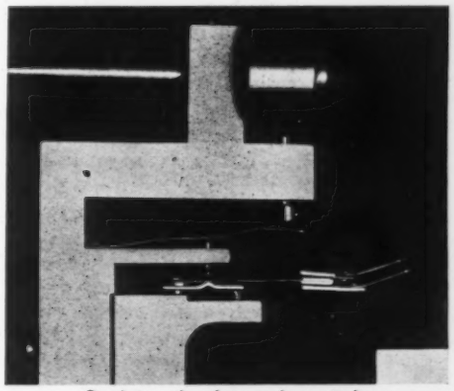
WRITE FOR BULLETIN 687

GENERAL RADIO COMPANY

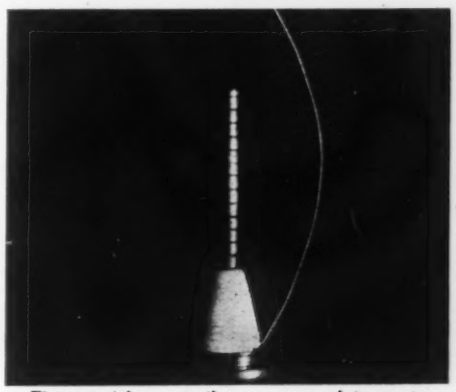
Cambridge, Massachusetts



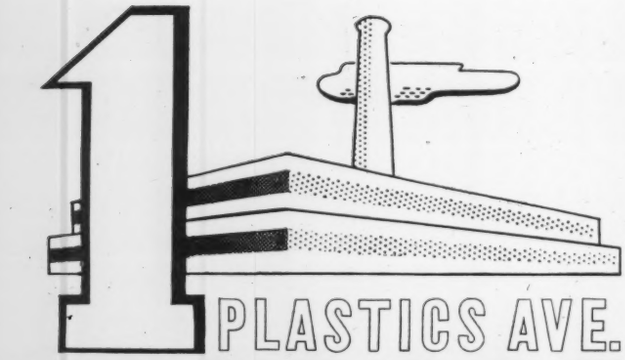
Shuttle of a loom being thrown 900 feet a minute



Studying the throw of a switch



This textile spindle was revolving at 10,000 rpm when the single-flash picture was taken



FOR THEIR COUNTRY AND THEIR CUSTOMERS

Plastics, more than ever before, is commanding the attention of engineers, designers and manufacturing men throughout the country.

With the tremendous requirements for these materials in the United States defense program, the consequent replacement of the non-ferrous metals with plastics and the natural growth in the number and type of applications, a terrific burden has been placed on the capacity of the industry.

General Electric believes this burden must be relieved and they have been taking steps to accomplish this end.

Already, G-E conducts the largest finished plastics manufacturing operation in the country. At One Plastics Avenue, Pittsfield, Mass. is the largest single molding unit of its kind. At Meriden, Conn. and Fort Wayne, Ind. are similar molding plants with a total capacity exceeding the Pittsfield factory. At Lynn, Mass. is a complete laminating operation for the manufacture of sheets, rods and tubes.

But with the onrush of business, this is not enough. During 1940, in addition to increasing their press capacity in their established plants, the Plastics Department erected a pilot plant in Pittsfield for small scale production of plastics. Today they are adding to this structure. Adjacent with One Plastics Avenue, a combination office and laboratory building is under construction.

And still the Plastics Department grows. At Taunton, Mass., G.E. is reopening and renovating its former motor factory for the production of more plastic molded parts.

It is the G-E Plastics Department's way of doing their level best for their country and their customers.

PD-155

PLASTICS DEPARTMENT
GENERAL ELECTRIC

stituting $B = l/d$ the stress ratios are

$$\frac{S_x'max.}{S_xmax.} = \frac{4}{15B^2}$$

$$\frac{S_ymax.}{S_xmax.} = \frac{4}{3B^2}$$

The values of these ratios for varying beam length ratio B are plotted in *Fig.* 24. It can be seen that for beams of the usual proportions the correction for S_x is negligible, and the value of S_y quite small.

The above conclusions for the case of *Fig.* 22 will apply to the general case illustrated by *Fig.* 18. The correction S_x' and the value of S_y are shown by *Fig.* 23. Curves similar to Fig. 24 cannot however be drawn for the general case, although the variation with B (B now considered as the ratio of loaded length to depth) will be similar. From this it may be stated that the S_x and v_{xy} stresses in the usual case of general bending, at sections away from the load discontinuities, is given with sufficient accuracy by elementary theory; and that S_y may usually be safely neglected.

Photoelastic Picture Confirms Findings

This is demonstrated by *Fig.* 26 which is a photoelastic picture of the portion of the beam indicated in the loading diagram of *Fig.* 25. The large block at the left, on top of the beam, is a soft mass that served to distribute the load approximately uniformly.

Between the uniform and the concentrated load $V = 2.8$ which gives $n = .25$. The "zero" band along the center line is grayish. Along the center line underneath the load $S_y = -10.5/b$ (from *Fig.* 23) and therefore at the section of zero shear $n = 10.5/H = .12$. It will be noticed that the gray band becomes practically black here. Proceeding to the left the shear increases, increasing the fringe order, the first order being reached just to the left of the center. Substituting in the equations shows $n = 1$ at .15-inch to the left of the center, which checks very closely with the photograph.

At the section of zero shear $M = 21.5$ inch-pounds giving S_x, by elemental theory, equal to $\mp 860/b$, top and bottom, $S_x' = \mp q/5 = \mp 4/b$ top and bottom, or ½ per cent of S_x. $S_y = -21/b$ at top, or 2½ per cent of S_x, and zero at the bottom. This gives n at the top = 9.75 and bottom 10. The photograph shows 9¼ top and bottom or an error of 5 and 7½ per cent.

Similarly, at the section at the left end of the load, $n = 6$ top and 6.3 bottom. The photograph shows 5¾ for both. Checking of other points will show equally good agreement.

It has also been shown that Equations 52, 53, and 54 are close approximations for the case of varying q, provided that the rate at which it varies is not too great[4]. In such case the value of q to be used is that at the section in question.

The system of Equations 52, 53, and 54 may be

[4] Timoshenko, Page 44.

(*Concluded on Page* 86)

A nearby "Logan" Representative will be glad to make recommendations on your own requirements.

"LOGAN" MANUFACTURES A COMPLETE LINE OF AIR OR HYDRAULIC EQUIPMENT AND CONTROLS...

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Logansport Machine, Incorporated
911 Payson Road Logansport, Indiana

We don't know what the "artist" who did the above drawing * had in mind — perhaps a bit of landscaping, or an airport — but he ended up in some words that do mean something—Micro-Weave All American Tracing Cloth. By every basis of test and comparison, this tracing cloth "measures up". If you haven't tried Micro-Weave — order it from your supply house — in the convenient container box.

* another in the series of "Doodle" drawings found on the margins of test sheets returned to us by draughtsmen.

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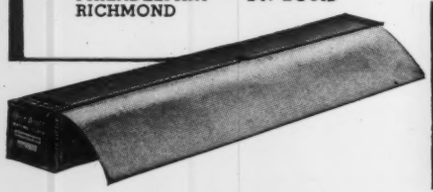

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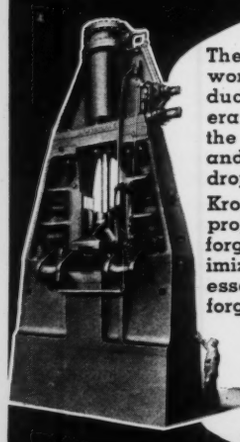

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KROPP
KROPP FORGE COMPANY
World's Largest Job Forging Shop
5307 W. Roosevelt Road
CHICAGO, ILLINOIS

(*Concluded from Page* 80)

applied also to the eccentrically loaded column in *Fig.* 27 by adding the system of direct stress, $S_x = -P/bd$, giving

$$S_x = -\frac{P}{bd}\left(1+6ey_1\right) \quad \ldots\ldots (59)$$

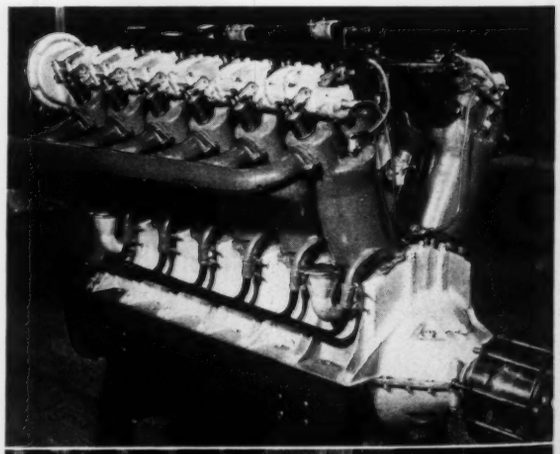
$$S_y = 0;\ v_{xy} = 0 \quad \ldots\ldots (60)$$

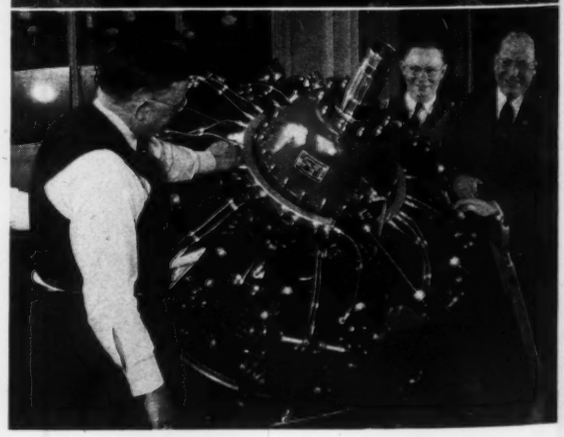
which checks with elementary theory. Similarly for a column with lateral loads in addition to the vertical, equations may be developed from the general equations of 52, 53 and 54. In cases of columns, however, the lateral deflection must be small enough not to appreciably effect the moment from the column load.

From this discussion of elastic theory, assisted by photoelastic photographs, it is apparent that the elementary theory of bending, and bending combined with direct stress, may be accepted as sufficiently accurate except for very short beams, and at points of concentrated loads, or loads partially distributed over very short lengths.

From Automobiles to Aircraft

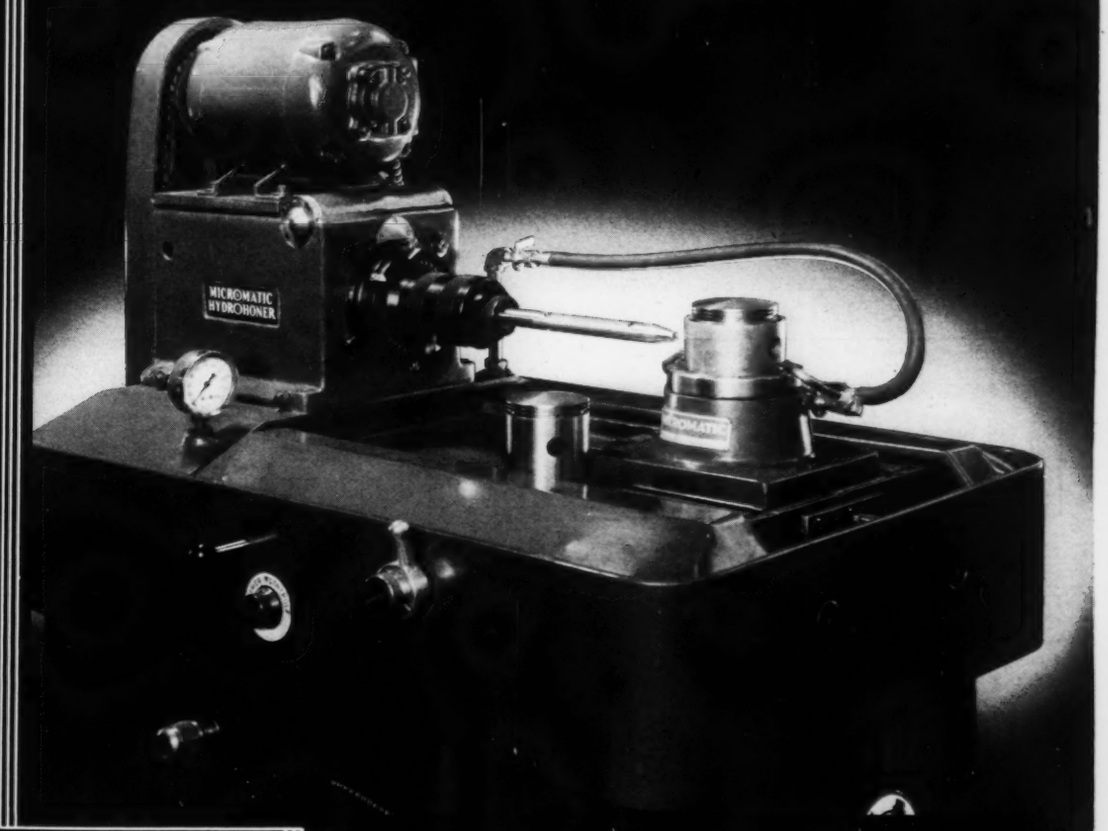
BACK to aircraft engine production, Buick will build the 1200-horsepower radial engine designed by Pratt & Whitney, illustrated below, at the rate of 500 a month in a new plant. The famous Liberty engine, produced in quantity by Buick during the previous war, also is shown.





New

Automatic MICRO SIZE Control WITH MICROMATIC HYDROHONER



For the first time in honing, this equipment makes completely automatic operation successful.

The Automatic Micr-O-Size Control Unit generates accurate sizing in high production, uniformly within limits from .0002" to .0005", reducing tolerance range and number of selective fits.

It offers increased production through simplified practice. Write for Bulletin A.R.-60.

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1517 WEST CARROLL AVENUE **CHICAGO, ILLINOIS**

FEL-PRO Gaskets
METALLIC PACKING

MEN OF MACHINES

(Continued from Page 52)

he has been development engineer for the Hall-Scott Motor Car Co., test engineer for Associated Oil Co., chief engineer of the Apache Radial Motor Corp., test engineer of Natural Gas Pipeline Co., investigation engineer of design and material, and later works metallurgist for Worthington Pump & Machinery Corp.

♦

K. P. ROLSTON, formerly chief engineer of Screw Machine Specialty Co., has become connected with Hunter Mfg. Corp., Bristol, Pa., in charge of mechanical production. The latter company is engaged in the manufacture of munitions and kindred materials for defense work.

♦

DR. C. A. GETZ has been named director of research of Cardox Corp., Chicago, manufacturer of coal mining equipment and fire extinguishing systems.

♦

DAVID C. PRINCE, manager of the commercial engineering department, General Electric Co., Schenectady, N. Y., has been nominated for president of the American Institute of Electrical Engineers.

♦

HORACE S. HUBBARD of General Electric Company's Pittsfield (Mass.) works was one of the recipients of the Charles A. Coffin Foundation awards, which the company gave for outstanding contributions made during 1940 to the progress of the organization and the electrical arts. Mr. Hubbard received his award for "development and design of a 1,400,000 volt direct-current generator for the National Bureau of Standards in Washington."

♦

CHARLES T. RAMSDEN, for the past 27 years consulting engineer of Beloit Iron Works, Beloit, Wis., has been elected a vice president. Mr. Ramsden joined the company 45 years ago as machinist.

♦

COMFORT AVERY ADAMS, consulting engineer, Edward G. Budd Mfg. Co., has been awarded the 1940 Lamme medal of the American Institute of Electrical Engineers "for his contributions to the theory and design of alternating current machinery and his work in the field of electric welding." The medal and certificate will be presented at the annual meeting of the institute in Toronto, June 16-20.

♦

RICHARD M. HUBER has been appointed project engineer of Transcontinental & Western Air Inc., succeeding M. TUCKER who resigned to accept a position with the Airport commission of Los Angeles. Mr. Huber will be in charge of the airways engineering department. WILLIAM M. SCHWARTZ, with TWA as an engineer since last November, succeeds Mr. Huber as airport engineer with the Transcontinental com-

WANTED

Young mechanical engineer with from two to four years experience in the design of machines and with the ability to express himself in writing. Age preferably between 25 and 28. Salary open. Position offers excellent opportunity for advancement in editorial capacity. Address Box 141, MACHINE DESIGN, Penton Bldg., Cleveland, O.

an Open Letter

to the users of Thermostatic Bi-metals or Electrical Contacts

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REFINERS AND WORKERS OF PLATINUM, GOLD AND SILVER
WILCO THERMOSTATIC METAL
BELAIS WHITE GOLD

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March 31, 1941

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Thermostatic bi-metal and electrical contacts are playing a role of ever increasing importance in National Defense as well as everyday use.

We pledge ourselves to a continuation of our policy of excellence in material, skill in manufacture, and painstaking care in the inspection of our products.

To this end we guarantee personal attention to every order regardless of the size.

Harry A. Wilson

HARRY A. WILSON
President

Now more than ever Personal Attention Counts

★ Today, emphasis throughout industry is placed primarily on *increased production.* And that's why accuracy in manufacture and painstaking care in inspection is more important than ever. By dealing with The H. A. Wilson Co. you eliminate entirely any worry on this score. Because—regardless of increased demands—the principals of this company will continue to supervise and check every order—*personally.*

105 CHESTNUT ST., NEWARK, N. J. *Branches:* CHICAGO, DETROIT

WILCO

THE H. A. WILSON CO.

PLASTIC MOLDED HANDLES are ideal for Portable Radios, Instrument Kits, Portfolios etc. Smooth, sanitary, pleasing to touch, they fit the hand perfectly. Will support 150 pounds. Made in two sizes: one 4⅜", the other 3½" between supports.

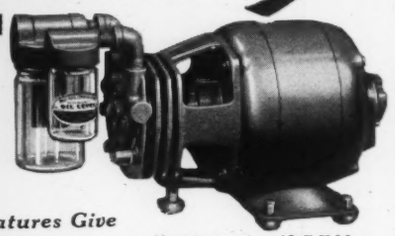
Stock colors are Black, Brown, Ivory, and Buckskin. Other colors special.

SEND FOR SAMPLES AND PRICES

CHICAGO MOLDED PRODUCTS CORP.
1028 N. KOLMAR AVE. — CHICAGO, ILL.

If Space Is Limited For

VACUUM PUMPS
ON YOUR MACHINES
Specify This
"GAST"
2NF10-VA ROTARY AIR PUMP



Scores of manufacturers have discovered by *actual comparative tests* that this compact Gast air pump, only 11½" x 6½" in size, solves the problem of limited space *without* sacrifice of economy, performance or durability.

These Famous Gast Features Give You Exceptional Performance

Nine Sizes—1 to 23 C.F.M. Vacuum To 28" Pressures to 30 pounds.

- **COMPACT**—Vacuum pump and rotor mounted on motor shaft.
- **EFFICIENT**—More air delivered per pound of weight and H.P. used.
- **ADAPTABLE**—Can be used as either vacuum or pressure pump.
- **DESIGN**—Cuts friction loss to a minimum.
- **AUTOMATIC OIL SEAL**—Eliminates shaft packing . . . Prevents oil leakage, vacuum loss, excessive friction, troublesome adjustments.
- **VANES**—Composition . . . No springs . . . automatic takeup for wear.
- **SIMPLICITY**—No gears, springs or reciprocating parts.

Write Today for complete Catalog, Performance Chart and Special Manufacturers' Discounts! **Gast Mfg. Corporation, 107 Hinkley St., Benton Harbor, Mich.**

GAST VACUUM PUMPS

pany; and CHARLES L. LUNDBLAD, formerly a radio engineer, has been appointed design engineer to replace GENE H. GORDON who has joined the Civil Aeronautics administration as an airport engineer.

♦

MARION P. CREWS has been appointed as chief of the CAA airworthiness section, bureau of safety regulation in Washington. He has for nine years been an aviation engineering official in government agencies and for the past two years chief of the Civil Aeronautics administration midwest aircraft airworthiness section at Kansas City.

♦

DR. PAUL D. MERICA, assistant to the president of International Nickel Co., New York, received a platinum medal from the council of the Institute of Metals in Great Britain in recognition of "distinguished services to nonferrous metallurgy," in connection with his "precipitation theory" of hardening developed in connection with research on aluminum alloys.

♦

EARL GINN has been elected vice president of Continental Motors Corp., and will be in charge of the direction of automobile engineering.

♦

DEXTER S. KIMBALL, dean emeritus of engineering, Cornell university, has been named impartial chairman of the Machine Tool Priorities committee, and RALPH E. FLANDERS, president, Jones & Lamson Machine Co., has been named administrator. GENERAL HAYES of the U. S. Ordnance Dept. will represent the Army and CAPT. ALMY, the Navy. FREDERICK V. GEIER, president, National Machine Tool Builders' association, will represent industry.

♦

RUDOLPH F. GAGG, formerly assistant chief engineer of Wright Aeronautical Corp., has been appointed assistant to the general manager, to work on special projects. Mr. Gagg joined the organization as an experimental engineer in 1930.

♦

CHESTER E. MINES has joined Jacobs Aircraft Engine Co. as resident engineer. He was formerly chief of the Engine Laboratory Design Section, Materiel division, U. S. Army Air Corps, at Wright Field.

♦

CHARLES E. WILSON, acting president of General Motors Corp. since WILLIAM S. KNUDSEN joined the national defense program, has been elected president of the corporation.

♦

DR. GEORGE A. CAMPBELL has been awarded the Edison medal for 1940 by the American Institute of Electrical Engineers "in recognition of his distinction as scientist and inventor and for his outstanding original contributions to the theory and application of electric circuits and apparatus."

♦

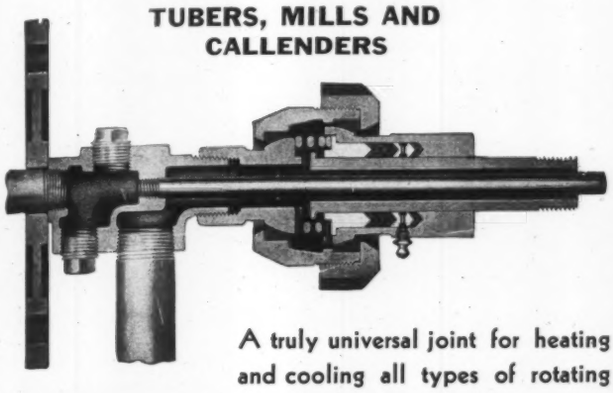
TOM TOWLE, identified for the past twenty years with major producers in the aircraft industry, as well as operating his own company, has been named head of the aeronautical eengineering section, aircraft division, Hudson Motor Car Co., Detroit.

BARCO

REVOLVING JOINTS

For water cooling or heating of

TUBERS, MILLS AND CALLENDERS



A truly universal joint for heating and cooling all types of rotating rolls. Eliminates packing troubles due to strains in ordinary stuffing boxes.

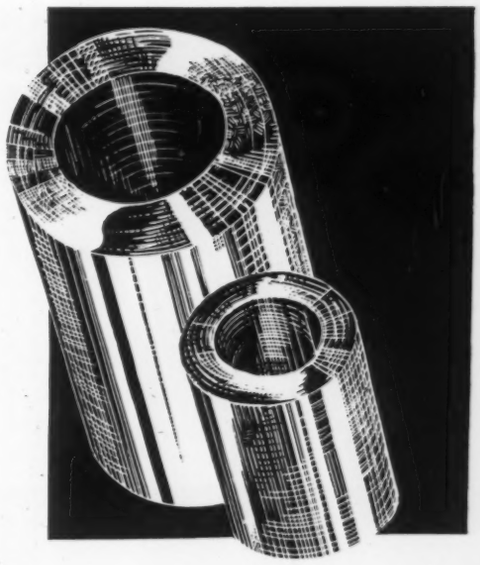
Barco Manufacturing Co.
1806 Winnemac Avenue, CHICAGO, ILL.
Not Inc.
In Canada: The Holden Co., Ltd.

1,000,000 pumps to date . . . here at Viking we're pretty proud of that accomplishment. But we know that what really counts, both with us and with you, is what these 1,000,000 pumps have done. Many Viking Rotary Pumps are still in use after 20 and 25 years of constant service. Viking installations are to be found in practically every industry, in all 48 states and in countries the world over. They have saved millions of pumping hours and dollars, made possible the production of many new products, helped streamline modern industry. In building 1,000,000 pumps we've learned a lot about pumping problems and how to solve them. Perhaps we can help you. Write for Bulletin 2500-40.

LOOK FOR THIS TRADEMARK—THE SIGN OF A GENUINE VIKING

VIKING PUMP CO.
CEDAR FALLS, IOWA.

FOR DEFENSE



...Against Inadequate Lubrication

MORGANITE SELF-LUBRICATING BEARINGS were developed for use in your new designs, whether small home appliances or industrial machines.

The uses? Where liquid lubricants wash away, dissipate from heat or become sluggish from cold. Where greasy liquids may cause spoilage of your product or where bearings are difficult to reach with lubricants. Morganite bearings are unaffected by extreme heat or cold.

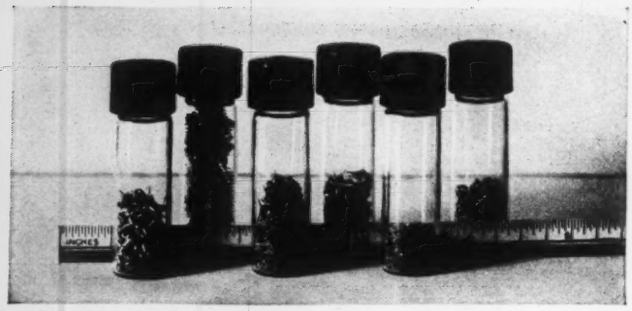
Won't you send the specifications of your new design? Morganite engineers will be glad to recommend the proper grade bearing or bushing to fit your needs.

Send for our informative bulletin "MODERN BLACK MAGIC".

MORGANITE BRUSH CO., INC.

TRADE MARK

Long Island City, New York



On the Microscopic Side

Peck Service includes helical springs for jewelry, scientific instruments, etc., so small they often have to be assembled under a glass. A few are shown above. The smallest of these are .0035" diameter, but they may be had even smaller! From these "atomic" sizes, Peck Springs grade up to 2" diameter, any stock, any type. Get acquainted with Peck Service. Send for catalog and technical

TREATISE ON SPRINGS

—a very useful document on how to order springs and get the most out of them. No charge, but please make request on your letter head.

PECK SPRINGS
AND SCREW MACHINE PARTS
The Peck Spring Co. **10 Wells St., Plainville, Conn.**

KOH-I-NOOR
Drawing Pencils

10c
EACH

Manufactured in U. S. A.

KOH-I-NOOR PENCIL COMPANY, INC.
373 Fourth Ave.
NEW YORK, N. Y.

Business and Sales Briefs

AMERICAN MAGNESIUM CORP. is now a wholly-owned subsidiary of Aluminum Company of America, following Alcoa's purchase of the half interest in the Magnesium Corp. formerly owned by General Aniline & Film Corp. In addition, four buildings and a tract of land have been purchased from the Crane Co. at Bridgeport, Conn., where an immediate expansion of facilities for magnesium castings for airplanes will be made. Output of castings has already been increased to 20 times the normal peacetime demand experienced in 1938.

♦

Instrument Specialties Co. Inc., beryllium copper spring manufacturer, announces its removal to a two-story plant at 244 Bergen boulevard, West Paterson, N. J. Former address was 379 Main street, Little Falls, N. J.

♦

I. F. Pohlmeyer has been appointed sales engineer in the Pacific Coast territory for the Ohio Seamless Tube Co., Shelby, O. Mr. Pohlmeyer formerly was associated with Globe Steel Tubes as inspection engineer.

♦

Pioneer Engineering & Mfg. Co. has occupied a new plant in Detroit which will augment its facilities for furnishing coolant and lubricant pumps.

♦

Appointment of Stewart J. Hieronymus as sales engineer in its San Francisco office is announced by the Lincoln Electric Co., Cleveland. Prior to his appointment, Mr. Hieronymus had been associated with Cutler-Hammer Inc. for 12 years.

♦

F. H. Lindus, formerly Los Angeles branch manager in charge of the service-sales division of the Timken Roller Bearing Co., has been transferred to the home office at Canton, O., where he is engaged in general promotional work. L. J. Halderman, branch manager of the service-sales division of the Chicago office, has taken Mr. Lindus' place at Los Angeles, while Jack Gelomb, formerly Detroit manager, has filled the Chicago vacancy. Joe Jesseph, resident salesman in the Portland, Ore., branch, has taken Mr. Gelomb's place at Detroit.

♦

T. P. Samuels has been transferred by Ampco Metal Inc., Milwaukee, from its home office to the Pacific coast territory, where he will work under the supervision of O. D. Cooper. Headquarters are at 918 North Clybourn avenue, Burbank, Calif. To head the development, production and distribution of Ampco-Trode coated aluminum bronze welding rods, Clinton E. Swift has joined the company in its Weldrod division. He has been associated with the welding industry since 1929, when he went with Westinghouse Electric & Mfg. Co., thereafter working for American Brass Co., C. F. Braun & Co., and Young Radiator Co.

♦

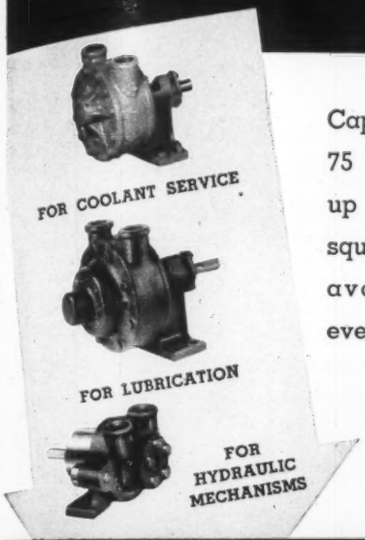
Walter L. Schneider succeeds Matthew A. Carpenter as sales manager in charge of active sales of The Falk Corp. line, with the exception of the foundry division. Mr. Carpenter, secretary of the corporation, will continue in a supervisory capacity over the sales, sales promotion and advertising department.

♦

Appointment of Lawrence E. Scrannage as general

AVAILABLE!

DEPENDABLE SMALL PUMPS



Capacities from 1/3 to 75 g.p.m. Pressures up to 400 lbs. per square inch. Types available to meet every requirement.

Write for Catalog Today

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941 EAST 95th STREET • CHICAGO, ILL.

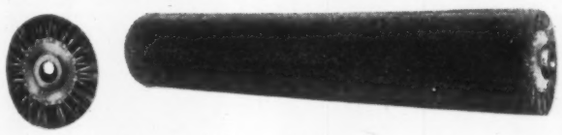
FULLER STEELGRIPT

THE MULTI-PURPOSE BRUSH CONSTRUCTION

DESIGNERS and Builders of machinery and equipment, utilizing brushes as an integral unit, approve Fuller Steelgript's enduring construction. Brush material is held, vise-like, in a durable, rust-resisting, all metal backing—no wood. Manufactured in strips, cut to specified lengths, it can be formed, shaped and spiraled to your requirements.

Steelgript's strong, rigid, metal backing requires only simple attachments for fastening into machinery. Replacements with refills quickly made.

Patented Fuller Steelgript is widely used on Packaging and Labeling equipment, Printing Presses, Bus and Car Washers, Textile, Steel and Tin production, Power Sweepers. Also used by Food, Bakery and Candy Manufacturers, Dairies, Bottlers, Flour Mills, Meat Packers and others.



Send your blue prints and specifications for quotations on your particular requirements

The FULLER BRUSH Company
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3 REASONS

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Starting with the selection of the wool, all the way through scientific manufacturing and inspecting, expert, seasoned felt men use every method known to modern felt-making to produce Felt which is *uniform* in density, blend, content, thickness, tensile and splitting strength. Your specifications are followed precisely.

2. CORRECT CUTTING

The proper cutting of felt parts requires sharp minds and eyes as well as correct tools. Precision machines depend on *precision* cut parts for their proper functioning and leading industrialists know from years of experience that they can rely on American Felt Cut Parts.

3. DELIVERY ON SCHEDULE

Our customers have the benefit of two sources of supply . . . our modern Cutting Shops at Detroit, Mich., and at Glenville, Conn. . . . each a complete unit . . . manned and managed by men who will see that your Production line is never slowed up by lack of Cut Felt Parts ordered from the American Felt Company.

Send for Data Sheet No. 5, containing complete data on approved S.A.E. Felts.

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